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RESEARCH AND ENGINEERING DEVELOPMENT

AVAILABILITY OF RESIDUAL FUEL OIL

TASK #2 FINAL REPORT

Submitted to

ENVIRONMENTAL PROTECTION AGENCY

AIR POLLUTION CONTROL OFFICE

DIVISION OF PROCESS CONTROL ENGINEERING

Contract No. CPA 70-68

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A DIVISION OF PULLMAN INCORPORATED

Research & Engineering Development

AVAILABILITY OF RESIDUAL FUEL OIL
TASK #2 FINAL REPORT
EPA-APCO-DPCE CONTRACT NO. CPA 70-68
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AVAILABILITY OF RESIDUAL FUEL OIL

TASK #2 FINAL REPORT

CONTRACT NO. CPA 70-68

Submitted to

ENVIRONMENTAL PROTECTION AGENCY

AIR POLLUTION CONTROL OFFICE

DIVISION OF PROCESS CONTROL ENGINEERING

by

THE M. W. KELLOGG COMPANY
RESEARCH & ENGINEERING DEVELOPMENT
PISCATAWAY, N.J.

December 31, 1970

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I. INTRODUCTION

The work described in this report was performed as Task #2 under Contract No. CPA 70-68 with the National Air Pollution Control Administration, Environmental Health Service, Public Health Service, Department of Health, Education, and Welfare.*

The objectives of this task were to estimate the present and future availability of residual fuel oil (RFO), relative to the United States market, at current high sulfur levels and at low sulfur levels.** These estimates were to be made on the basis of available data to be obtained from government publications, trade journals, etc. However, as work progressed it became apparent that the available published data dealing with foreign RFO production capability were inadequate for the development of a meaningful analysis of the imported RFO supply picture. Consequently, it was decided that the best method of obtaining the necessary data was through the use of a questionnaire submitted directly to the appropriate companies. In following this latter procedure, the questionnaire has been limited to those Caribbean and South American refineries that are the main suppliers of RFO to the United States.

The study actually consisted of two phases, as follows:

Phase 1

Compilation of statistical data relating to the recent history of the crude oil and residual fuel oil situation throughout the world with particular emphasis on the United

* Recently changed to Air Pollution Control Office, Environmental Protection Agency.

** RFO containing less than 1% S is defined as low sulfur while high sulfur refers to percentages above 1%.

States. These statistics include data covering total crude runs to stills, total installed refining capacity, residual fuel oil production and demand, fuel oil imports and exports, fuel oil consumption by end use, fuel oil price as a function of sulfur content, fuel oil transportation costs, and sulfur content of domestic and imported fuel oils.

Phase 2

Estimation of the present and future production capability of existing refineries, domestic and foreign, which are engaged in supplying the United States residual fuel oil requirements.

Projection of the RFO production capabilities of these same refineries after the addition of hydrotreating facilities and the incremental cost of producing low sulfur RFO as a result of such modifications.

In those cases where estimates of future statistical data were required for both phases 1 and 2, the data projections have been carried through the period 1971-75.

II. SUMMARY AND CONCLUSIONS

A. Domestic RFO Production

Domestic production of RFO has been systematically reduced from 11.25 to 6.85 volume percent of the total crude run during the period 1960 to 1969. This was done to maximize profits by increasing the production of the more valuable light petroleum fractions. On a short term basis, such as during the current 1970-71 winter season, the trend toward minimizing RFO may be temporarily reversed. Long term, however, the trend is expected to continue but at a substantially lower rate of change in the decrease of the volume percent of crude going to RFO production.

Domestic RFO production for the period 1971-1975 is estimated to be in the 750,000 to 850,000 BCD* range, of which 150,000 to 175,000 BCD are estimated to be in the 0-1.0% sulfur content range. The addition of heavy residuum hydrotreating facilities to reduce the overall domestic RFO pool to 1% sulfur content would decrease total RFO production by about 10% to the 675,000-750,000 BCD level. A capital investment of roughly 300 to 400 million dollars would be required and the incremental production costs would vary from $0.75 to $1.85 per barrel with an overall U.S. average in the $0.75 to $0.90 per barrel range.

Reduction of the domestic pool to a 0.5% sulfur content via hydrotreating would decrease total RFO production by about 25% to the 550,000-625,000 BCD range. A capital investment of roughly 700 to 1100 million dollars would be required and the incremental production costs would vary from $0.90 to $2.25 per barrel with an overall

*Barrels Per Calendar Day

U.S. average in the $0.95 to $1.15 per barrel range. For comparison, the September 1970 spot price in New York Harbor showed a premium of $0.55 to $1.05 per barrel for maximum 1% sulfur No. 6 FO versus no sulfur guarantee No. 6 FO containing over 2.2% sulfur.

B. Foreign RFO Supply Potential

1. Eastern Hemisphere

Eastern Hemisphere (Western Europe and Middle East) imports have increased from less than 5% (1964) to 14.2% (Jan./May 1970) of the total U.S. RFO imports. Largely responsible for this increase is the availability of low sulfur RFO from Western Europe made possible by the processing of low sulfur African crudes. The potentially available Eastern Hemisphere imports are estimated at 225,000 to 300,000 BCD for the 1971-75 period. Of this total about 100,000 to 200,000 BCD will be in the 0-1% sulfur content range. Since this quantity represents less than 20% of the total Western Europe production of RFO, it should be possible on a short term basis to increase the supply potential from this area by competitive bidding for a larger share of the total production.

2. Western Hemisphere

Western Hemisphere (Venezuela, Trinidad, Netherlands Antilles, Virgin Islands and Bahamas) production over the period 1965-69 averaged 1,385,000 BCD of which 70% was imported into the United States. Based on questionnaire data obtained by Kellogg, the production capability of RFO will increase by 6% per year, from 1,690,000 BCD in 1970 to 2,250,000 BCD in 1975. The production of low sulfur RFO will increase by 16% per year, from 550,000 BCD in 1970 to 1,140,000 BCD in 1975. The United States probably will continue to import the major portion of the Western Hemisphere production.

C. United States Supply/Demand Analysis

The total world RFO supply potential versus United States demand shows a RFO surplus for the years 1971, 1972 and 1973 of 317,000, 192,000 and 61,000 BCD respectively. For 1974 and 1975 it shows a deficit of 94,000 and 204,000 BCD respectively. In order to meet the United States demands for the years 1971, 1972 and 1973 ,however, it will be necessary to increase the percentage of total Western Hemisphere production which is imported into the United States from 73% in 1969 to 97% in 1973 and/or increase imports from the Eastern Hemisphere. To the extent that it would not be possible to obtain this great a portion of the Western Hemisphere output, the deficit predicted for 1974 would occur at some earlier date.

The total world supply potential of 0-1.0% sulfur content RFO versus United States demand shows a deficit of 64,000 BCD for 1971, increasing to 532,000 BCD in 1975. The United States RFO supply/demand statistics (see Table 22) are based on the best available statistical data combined with reasonably conservative estimates. Since the many factors influencing both supply and demand are constantly changing, these data are intended to be indicative of representative trends rather than firm quantitative values. However, it can be concluded with reasonable certainty that the U.S. will experience a chronic RFO shortage no later than 1973-74 and a low sulfur RFO shortage beginning in 1971 if prompt action is not taken to increase the world supply potential.

D. Potential Modifications to World RFO Supply

The short term methods used by the industry to increase RFO supply potential in response to the rapid growth in demand apparently will be adequate to meet U.S. demand for no sulfur limit RFO for the next three or four years but will not be adequate to meet low sulfur RFO requirements thru 1971. Therefore on a long term basis the solution of the RFO supply problem will require some modification and considerable acceleration of present plans to expand Western Hemisphere RFO production capability.

Domestic production of high sulfur RFO is being increased by 100,000 to 200,000 BCD during the 1970-71 winter season. This incremental production should be continued for as long as is necessary to remove the pressure on the continued increase in imported RFO prices. The industry also should take steps to reduce the current sulfur level of the domestic RFO pool to alleviate the low sulfur RFO shortage, assuming of course that an adequate price incentive will be maintained on a long term basis.

As a short term solution to the low sulfur RFO shortage, imports from the Eastern Hemisphere should be continued and increased to the extent possible without raising prices excessively. From a long term standpoint, however, the continued growing reliance on Western Europe for RFO supply is not as desirable as increased domestic and Western Hemisphere production. This is true because of the following factors: 1) the latter production sources are controlled by U.S. firms and consequently are more responsive to changes in U.S. demand; 2) shipping distances from South America and the Caribbean as compared to Eastern Hemisphere sources are shorter thus requiring a smaller tanker fleet; and 3) Eastern Hemisphere supply potential is subject to change owing to many factors, such as air pollution restrictions, which are outside the control of U.S. based oil companies.

Probably the most satisfactory long term solution to the RFO supply problem would be to accelerate the increase in the production capability of Western Hemisphere refineries. It should be noted that presently planned expansions through the year 1973 are inadequate to meet the growing demand, particularly for low sulfur RFO. To facilitate the needed expansion, it will be necessary to develop long term stable supply sources for low sulfur African crudes, long term adequate price incentives and methods for the disposition of the light petroleum fractions which are essentially byproducts in the Caribbean and South American producing areas.

III. DATA ORGANIZATION

A. Data Sources

The primary data sources for crude petroleum and petroleum product statistics are the mineral industry survey reports published by the United States Department of the Interior, Bureau of Mines. The major part of the data compiled for phase 1 was obtained from four Bureau of Mines publications: "Petroleum Statement, Annual", "Burner Fuel Oils, Annual", "International Petroleum, Annual", and "Fuel Sales, Annual".

Residual fuel oil prices were obtained from "Platt's Oil Price Handbook" and "Platt's Oilgram" daily price service. Secondary data sources including the "World Petroleum Report", "Petroleum Facts and Figures" (API), "Annual Statistical Review" (API) and the "Oil and Gas Journal" were also used extensively.

B. Reporting Periods

The most recent calendar year for which complete fuel oil statistics have been compiled and published is 1968. Therefore, 1968 was selected as a basis and the basic phase 1 data for this year are presented in Tables 1-8, 11 and 13.

In some cases, where current data are essential to indicate changing trends such as for fuel oil prices and fuel oil demand statistics, the latest available data which cover all of 1969 and a part of 1970 have been included.

C. Geographical Reporting Areas

The geographical region divisions used in this study are the same as those used by the Bureau of Mines for reporting petroleum data.

Domestic statistics are reported on a nation-wide basis or by Petroleum Administration for Defense (PAD) district (Figure 1).

International statistics are reported in the "International Petroleum Annual" on the basis of seven world areas, and with one minor modification, these areas also have been used in the present study. The modification consisted of dividing the North American area into two districts covering the United States separately and Canada, Mexico and Bermuda combined, thus producing a total of eight areas.

IV. STATISTICS OF RECENT HISTORY OF FUEL OIL

The phase 1 objectives (defined in Section I of this report) comprise the compilation of statistical data covering all aspects of the production and consumption of residual fuel oil. The data are reported in both tabular and graphical form with specific tables and figures related to the individual objectives as follows:

Task Order Item	Table No.	Figure No.
1	1, 3, 15	-
2	2, 15	-
3	6, 7	3, 4
4	4, 5, 16	1, 2
5	8, 9	5, 6

Additional statistics not specifically covered by the task order but which have been compiled at the request of NAPCA are given in Tables 10-14 and Figures 7-9.

The tables and figures that are shown above (i.e., Tables 1-16 and Figures 1-9) are discussed individually with respect to reporting periods, general content, method of calculation, and purpose. This discussion is given immediately below.

Tables 1 and 2 include refining data for the non-communist world subdivided into eight world districts. These data cover total refinery throughput, fuel oil production, net fuel oil imports and exports

TABLE 1

TOTAL REFINERY THROUGHPUT AND FUEL OIL PRODUCTION BY GEOGRAPHIC AREA - 1968
(NON-COMMUNIST WORLD)

(All Quantities in 1000 Barrels)

Area	Total Refinery Thruput	Domestic Crude		Imported Crude		Fuel Oil Production			
						Distillate FO		Residual FO	
		% Total		% Total		% Total		% Total	
United States	4,063,000	87.5	3,555,125	12.5	507,875	20.7	839,373	6.8	275,814
Canada, Mexico and Bermuda	576,891	69.2	399,485	30.8	177,406	24.5	141,127	18.2	104,742
Central America and Caribbean	184,578	0.6	1,062	99.4	183,516	20.2	37,320	35.0	64,510
South America	1,298,726	58.1	754,187	41.9	544,539	15.6	202,215	49.1	637,568
Western Europe	3,621,460	3.8	135,857	96.2	3,485,603	27.3	987,073	34.1	1,234,408
Middle East	711,589	73.4	522,406	26.6	189,183	20.0	142,098	43.6	309,953
Africa	212,303	60.2	127,864	39.8	84,439	22.0	46,711	33.4	70,903
Asia	1,529,419	9.7	148,629	90.3	1,380,790	15.3	234,143	41.1	628,814
Total	12,197,966	46.3	5,644,615	53.7	6,553,351	21.6	2,630,060	27.3	3,326,712

Data From "International Petroleum Annual 1968", Bureau of Mines
Mineral Industry Surveys, Annual Petroleum Statement 1968, Bureau of Mines

TABLE 2

NET FUEL OIL IMPORT, EXPORT AND CONSUMPTION BY GEOGRAPHIC AREA - 1968
(NON-COMMUNIST WORLD)

(All Quantities in 1000 Barrels)

Area	Net Fuel Oil Imports		Net Fuel Oil Exports		Net Fuel Oil Consumption	
	DFO	RFO	DFO	RFO	DFO	RFO
United States	48,148	409,928	-	-	887,521	685,742
Canada, Mexico and Bermuda	18,367	27,939	-	-	159,494	132,681
Central America and Caribbean	-	13,789	8,064	-	29,256	78,299
South America	-	-	75,126	433,912	127,089	203,656
Western Europe	93,413	35,005	-	-	1,080,486	1,269,413
Middle East	-	-	74,256	138,560	67,842	171,393
Africa	16,643	4,675	-	-	63,354	75,578
Asia	30,702	17,567	-	-	264,845	646,381
Total	207,283	508,903	157,446	572,472	2,679,887	3,263,143

Data From "International Petroleum Annual 1968", Bureau of Mines
Mineral Industry Surveys, Annual Petroleum Statement 1968, Bureau of Mines

Fuel Oil Consumption values neglect change in inventory.

and net consumption. The net fuel oil import or export figures represent the sum of the exports and imports for each area. It is evident from the data in these tables that South America and the Middle East areas are the only net exporters of RFO while the United States is the major importer, receiving about 80% of the world total of imported RFO.

It also is evident from Tables 1 and 2 that although the United States is a major consumer of RFO, (only Western Europe uses more) it produces the least amount based on volume percent of total refinery throughput. On this latter basis, the 1968 production of RFO is shown in Table 1 for the non-communist world and is seen to range from a low of 6.8% in the United States to a high of 49.1% in South America, with an overall average of 27.3%. The world consumption of fuel oil shown in Table 2 differs from the world production listed in Table 1 by the amount of inventory change which is neglected in these tables. Further, it should be noted that the sizable discrepancy between the total export and import quantities shown in Table 2 is not explained in the data source.

Table 3 includes total refinery throughput, total operable refining capacity, and total throughput as percent of total refining capacity, i.e., stream efficiency. The overall average stream efficiency is 91% ranging from a low of 80.7% for Africa to a high of 97.5% for South America with the United States second at 95.1%.

Table 4 shows the quantity of fuel oil transferred between PAD districts broken down by method of transfer. It should be noted that residual fuel oil is not transferred between PAD districts by pipeline. The net transfer data indicate that PAD districts 1 and 2 are net importers and districts 3 and 5 are net exporters of RFO. No transfer of RFO was made into or out of district 4 during 1968. Figure 1 shows the PAD district boundaries superimposed on a map of the United States.

Table 5 includes domestic fuel oil production, foreign fuel oil imports and net fuel oil consumption broken down by PAD district. Net fuel oil consumption is the sum of the net transfer from other PAD districts, foreign imports and domestic production. Again, inventory changes are neglected. It is obvious from Table 5 that PAD district 1 is the major consumer of foreign imports, receiving over 95% of the total.

Table 6 includes a yearly arithmetic average sulfur content of each grade of domestically produced fuel oil for the years 1968 and 1969, broken down by PAD district. Also shown are the minimum and maximum sulfur values of the samples used in the calculation of the arithmetic averages. These data are reported in the "Burner Fuel Oils, Annual" (1-a) for geographical areas that differ slightly from the PAD districts (Figure 1) used elsewhere in this report; therefore, to maintain a consistent basis, the data have been adjusted to conform to the PAD districts.

TABLE 3

TOTAL REFINERY THROUGHPUT AND TOTAL OPERABLE REFINING CAPACITY
BY GEOGRAPHIC AREA - 1968
(NON-COMMUNIST WORLD)

Area	(1) Total Refinery Thruput Bbl/Day	(2) Total Operable Refining Cap. Bbl/Day	Total Thruput As % of Total Refining Cap.
United States	11,100,000	11,658,000	95.1
Canada, Mexico and Bermuda	1,576,000	1,733,000	91.0
Central America and Caribbean	504,000	540,000	93.3
South America	3,548,000	3,639,000	97.5
Western Europe	9,895,000	11,598,000	85.4
Middle East	1,944,000	2,154,000	90.3
Africa	580,000	719,000	80.7
Asia	4,179,000	4,542,000	92.0
Total	33,327,000	36,573,000	91.0

(1) Aver. for entire year: Source, Inter. Pet. Annual 1968
(2) As of Jan. 15, 1969, World Petroleum Report, 1969

TABLE 4

FUEL OIL TRANSFERS BETWEEN PAD DISTRICTS - 1968

(All Quantities in 1000 Barrels)

PAD District	Method Used To Transfer Fuel Oil	DFO			RFO		
		In	Out	Net	In	Out	Net
I	Pipeline	160,515	6,827	153,688	-	-	-
	Tanker	122,704	-	122,704	35,083	-	35,083
	Barge	1,452	-	1,452	332	-	332
	Total	284,671	6,827	277,844	35,415	-	35,415
II	Pipeline	20,344	5,375	14,969	-	-	-
	Barge	8,542	-	8,452	6,926	-	6,926
	Total	28,886	5,375	23,511	6,926	-	6,926
III	Pipeline	5,176	175,512	170,336	-	-	-
	Tanker	-	123,884	123,884	-	35,047	35,047
	Barge	-	9,994	9,994	-	7,258	7,258
	Total	5,176	309,390	304,214	-	42,305	42,305
IV	Pipeline	543	7,059	6,516	-	-	-
V	Pipeline	8,195	-	8,195	-	-	-
	Tanker	1,363	183	1,180	62	98	36
	Total	9,558	183	9,375	62	98	36

DFO = Distillate Fuel Oil
RFO = Residual Fuel Oil

Data Source: Bureau of Mines Annual Petroleum Statement

TABLE 5

SUMMARY OF FUEL OIL PRODUCTION, IMPORTS AND CONSUMPTION BY PAD DISTRICT - 1968

(All Quantities in 1000 Barrels)

PAD District	Domestic Fuel Oil Production		Foreign Fuel Oil Imports		Net Fuel Oil Consumption		Net Fuel Oil Consumption			
							DFO		RFO	
	DFO	RFO	DFO	RFO	DFO	RFO	% Import	% Prod.	% Import	% Prod.
I	132,580	40,829	45,502	394,528	455,926	470,772	70.9	29.1	91.3	8.7
II	233,735	56,050	360	573	257,606	63,549	9.3	90.7	11.8	88.2
III	368,991	60,015	1,290	8,271	66,067	25,981	11.8	88.2	0	231.0
IV	32,138	10,765	-	54	25,622	10,819	0	125.4	0.5	99.5
V	71,929	108,155	996	6,502	82,300	114,621	12.6	87.4	5.7	94.3
Total	839,373	275,814	48,148	409,928	887,521	685,742	-	-	-	-

Fuel Oil Consumption values neglect change in inventory.

Data Source: Bureau of Mines Annual Petroleum Statement

TABLE 6

SULFUR CONTENT OF DOMESTIC FUEL OILS
GRADES 1, 2, 4, 5, 6 BY PAD DISTRICT - 1968 AND 1969

PAD District	Fuel Oil Grade	Sulfur Content, Wt. % Range 68/69 Min.	Range 68/69 Max.	Arith. Average 1968	Arith. Average 1969
I	1	0.00	0.22	0.05	0.05
	2	0.03	0.48	0.19	0.20
	4	0.45	2.0	1.0	0.96
	5 (Light)	0.65	1.8	0.97	1.0
	5 (Heavy)	0.60	1.3	0.96	0.88
	6	0.60	2.9	1.3	1.4
II	1	0.00	0.45	0.10	0.11
	2	0.05	0.56	0.28	0.28
	4	0.22	2.0	0.87	0.78
	5 (Light)	0.60	3.4	1.4	1.4
	5 (Heavy)	0.60	3.4	1.4	1.5
	6	0.52	4.1	1.5	1.7
III	1	0.00	0.41	0.14	0.15
	2	0.02	0.37	0.23	0.22
	4	0.39	0.98	0.75	0.69
	5 (Light)	0.98	1.4	1.3	1.2
	5 (Heavy)	1.5	3.4	2.1	2.3
	6	1.2	3.3	2.1	2.2
IV	1	0.01	0.19	0.07	0.06
	2	0.16	0.64	0.36	0.32
	4	1.0	2.7	2.2	1.9
	5 (Light)	1.9	3.0	2.6	2.4
	5 (Heavy)	1.0	3.0	2.0	1.7
	6	1.1	3.3	2.2	2.2
V	1	0.00	0.56	0.14	0.11
	2	0.02	0.74	0.28	0.26
	4	1.0	2.7	1.9	1.9
	5 (Light)	3.0	3.4	3.4	3.0
	5 (Heavy)	0.58	2.0	1.4	1.2
	6	0.69	2.4	1.2	1.3

Data Source: Bureau of Mines, Petroleum Products Survey, "Burner Fuel Oils", 1968 & 1969

REFERENCE:
Mineral Industry Surveys, U.S. Department of the Interior,
Bureau of Mines Petroleum Statement, Annual (1968).

FIGURE 1
PETROLEUM ADMINISTRATION FOR DEFENSE (PAD) DISTRICTS

REFERENCE:
Mineral Industry Surveys, U.S. Department of the Interior,
Bureau of Mines Petroleum Statement, Annual (1968).

FIGURE 2

BUREAU OF MINES REFINING DISTRICTS

REFERENCE:
Mineral Industry Surveys, U.S. Department of the Interior,
Bureau of Mines, Petroleum Products Survey No. 56.

FIGURE 3

GEOGRAPHICAL AREAS OF THE NATIONAL SURVEY OF BURNER-FUEL OILS

Also shown for comparison are the Bureau of Mines Refining Districts (Figure 2) and the Geographical Areas of the National Survey of Burner Fuel Oils (as shown in Figure 3). Figure 4 illustrates graphically the trends in sulfur content for RFO grades 4, 5 and 6 covering the period 1962-1969. The data used in this plot are taken from the reference cited above (i.e., 1-a).

The expression "current sulfur level" as used in this report is defined as the weighted average sulfur content of the domestic RFO pool. It also applies to the imported RFO pool. The actual value for the current sulfur level is not known accurately for the years 1960-1969 with the exception of 1965 when a study (6-b) was made by polling United States refiners. Based on data representing 66% of the total RFO production for 1965, the current sulfur level was calculated to be 1.76% W. All other published studies and literature references, which have been encountered in this study use the sulfur content values shown in the "Burner Fuel Oils, Annual"; however, as was pointed out previously, these latter values are arithmetic averages based on limited sampling. This lack of detailed data presents a serious handicap, particularly when the intended analysis stresses the role of sulfur content.

The "Burner Fuel Oil, Annual" data indicate that for the period 1964-1969 the current sulfur level has remained essentially constant with perhaps a slight increase. It should be noted that for the year 1965 the arithmetic average RFO pool sulfur is listed as 1.65% W versus the 1.76% W value cited in the preceding paragraph. Since these data are not statistically accurate enough to establish a trend, the range of 1.65 to 1.85% W was selected as indicative of the current sulfur level of the domestic RFO pool for the period 1965-1975.

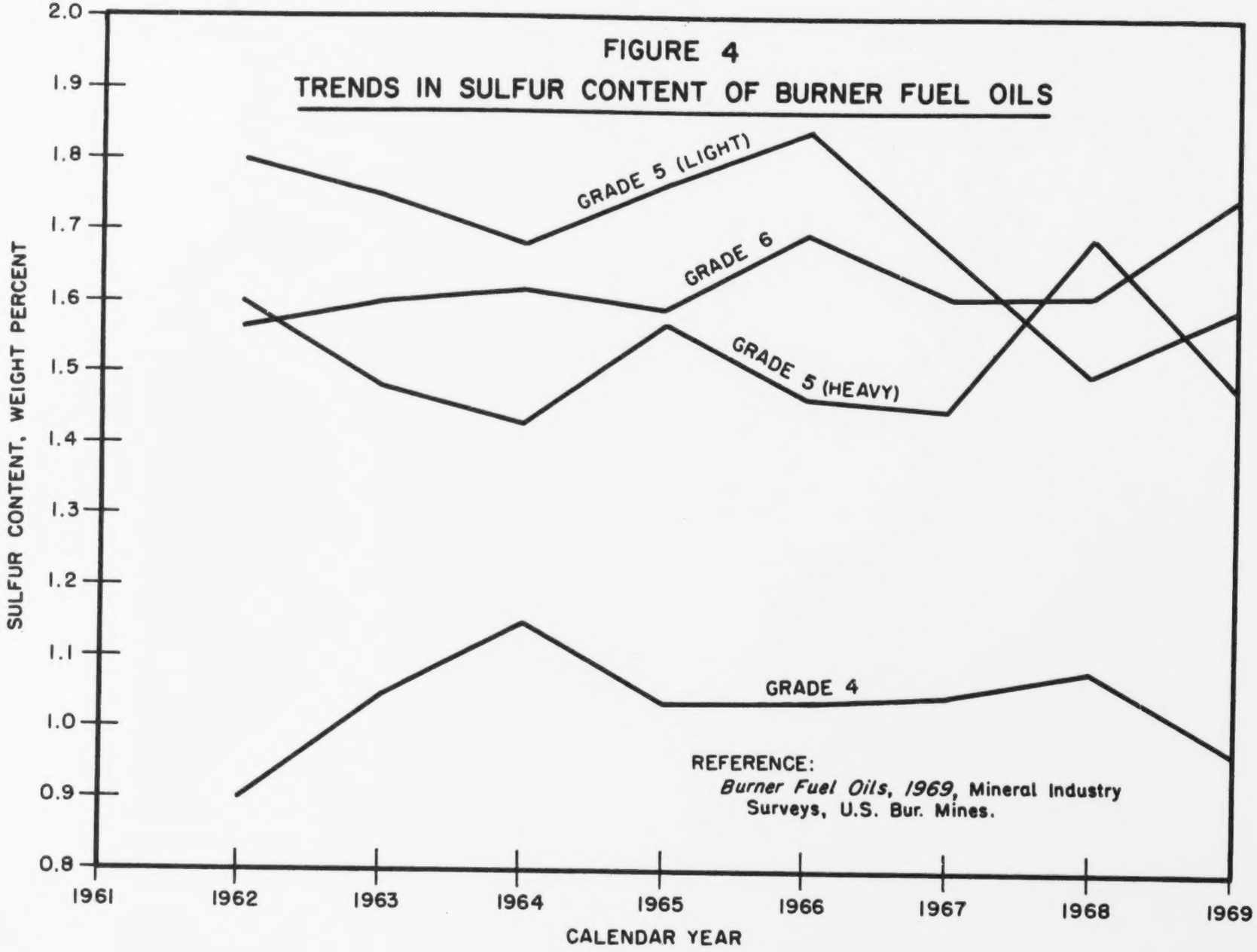


FIGURE 4
TRENDS IN SULFUR CONTENT OF BURNER FUEL OILS
GRADE 5 (LIGHT)
GRADE 6
GRADE 5 (HEAVY)
GRADE 4
REFERENCE:
Burner Fuel Oils, 1969, Mineral Industry Surveys, U.S. Bur. Mines.
SULFUR CONTENT, WEIGHT PERCENT
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
1961
1962
1963
1964
1965
1966
1967
1968
1969
CALENDAR YEAR

Table 7 reports the sulfur content of the RFO imported into PAD district 1 for the years 1968 and 1969. Since the sulfur content data are given for a range, the exact weighted average for the total import pool cannot be calculated. However, by assuming a minimum value of 0.5% W for the "0-1%" category and a maximum value of 3.0% W for the "over 2.2%" category, it is possible to calculate minimum and maximum weighted average sulfur content values that probably are quite close to the actual value. For 1968 and 1969 these calculated values are 1.6% min/2.3% max and 1.5% min/2.1% max, respectively. These results indicate a small reduction in the overall pool sulfur content for 1969 owing to the greater percentage of less than 1% sulfur fuel oil imported that year. The percentage of under 1% sulfur RFO imported into PAD 1 increased from 13.8 in 1968 to 22.5 in 1969 while the volume of imports increased by 12% from a daily average of 149,205 barrels per calendar day (BCD) to 272,146 BCD for the same period. The total volume imported in 1970 is expected to increase about 17% over the 1969 level, and most of the increase will be low sulfur fuel oil.

Data relating to the sulfur content of imported fuel oil are not published by the Bureau of Mines. However, for each shipment of fuel oil into the United States, documents which specify quantity, sulfur content and point of origin are available at the office of the Oil Imports Administration. At present, these documents (i.e., shipping invoices) are filed (by month) in their original form and receive no further treatment. Compilation and publication of these data would prove very useful to future studies relating to RFO.

TABLE 7

SULFUR CONTENT OF FOREIGN IMPORTS OF RESIDUAL FUEL OIL
TO PAD 1 DISTRICT - 1968 AND 1969

Sulfur Content Wt. %	1968 Average Bbl/Day No. 4	1968 Average Bbl/Day No. 5 & 6	1968 Average Bbl/Day Total	1968 % of Total	1969 Average Bbl/Day No. 4	1969 Average Bbl/Day No. 5 & 6	1969 Average Bbl/Day Total	1969 % of Total
0-1.0	4,157	145,048	149,205	13.8	20,429	251,717	272,146	22.5
1.01-1.5	14,064	58,497	72,561	6.7	9,910	74,347	84,257	7.0
1.51-2.2	30,286	433,558	463,844	43.0	30,708	434,577	465,285	38.5
over 2.2	1,588	390,747	392,335	36.5	14,471	372,013	386,484	32.0
Total	50,095	1,027,850	1,077,945	100.0	75,518	1,132,654	1,208,172	100.0

	1968		1969	
Calc. Min. Overall Sulfur Content	1.6 Wt. %	-	1.5 Wt. %	-
Calc. Max. Overall Sulfur Content	2.3 Wt. %	-	2.1 Wt. %	-
Total Imports to PAD I, Bbl/Year	394,528,000	96.2%	440,983,000	95.5%
Total Imports to U.S., Bbl/Year	409,928,000	100%	461,611,000	100%

Data Source: Private Communication, Asiatic Petroleum Corp.

Table 8 is a compilation of residual fuel oil prices for East Coast ports, Gulf ports and inland districts for the years 1968 and 1969 with spot prices up to 9/28/70. It can be seen that fuel oil prices remained almost constant during 1968, 1969 and the first quarter of 1970. From about April 1970 until the present, however, prices have increased very rapidly owing to a variety of reasons which include increased demand for low sulfur fuel oil and a tanker shortage. The posted price in New York harbor for high sulfur No. 6 fuel oil increased by 39% between March and September 1970, and by 60% for maximum 1% sulfur No. 6 fuel oil during the same period. Concurrently, price increases of the same magnitude were in effect throughout the United States.

Table 9 lists posted railroad shipping rates for residual fuel oil in tank cars, 15,000 gallons and larger, for distances up to 300 miles. It should be noted that special contract rates which differ considerably from posted rates are common but these must be calculated on an individual basis. Figures 5 and 6 show the data in Table 9 graphically.

Table 10 is a compilation of the detailed ASTM specifications applicable to the six grades of distillate and residual fuel oil.

Tables 11 and 12 present total sales of residual fuel oil in the United States by end use for the years 1964 through 1975. Projected sales for the period 1970-1975 are based on the total demand projection shown in Table 19 and the trend of end use as a percent of the total, for the period 1964-1969, from Table 11. Figure 7 shows the actual and projected sales of RFO, as a percentage of total sales, for each use category for the

TABLE 8

AVERAGE RESIDUAL FUEL OIL PRICES FOB TERMINAL ($/BBL)
FOR EAST COAST PORTS, GULF PORTS AND INLAND DISTRICTS

East Coast Ports

Period Ending	New York Harbor					New Jersey			Baltimore			
	No. 4	No. 5	No. 6			No. 4	No. 5	No. 6	No. 4	No.5	No. 6	
	Max 1%S	Max 1%S	NSG	Max 1%S	Max 2.2%S	Max 0.7%S	Max 1%S	Max 1%S	Reg.	Reg.	NSG	Max 1%S
12/68	3.19	2.83	2.20	2.50	2.35	3.30	3.05	2.50	3.38	3.12	2.33	-
6/69	3.19	2.83	2.20	2.48	2.35	3.30	3.05	2.53	3.38	2.94	2.15	-
12/69	3.15	2.83	2.20	2.48	Discon-	3.25	3.05	2.51	3.38	2.82	2.18	-
3/70	3.15	2.83	2.20	2.55	tinued	3.30	3.12	2.58	3.09	2.82	2.04	-
5/70	3.49	3.33	2.37	2.93	-	3.72	3.47	2.96	3.33	3.05	2.28	-
7/20/70	3.76	3.72	2.70	3.25	-	3.97	3.74	3.25	3.59	3.32	2.54	-
8/31/70	4.11	4.07	3.05	3.60	-	4.32	4.09	3.60	3.94	3.67	2.89	-
9/28/70	4.11/4.39	4.07	3.05	3.60/4.10	-	4.32	4.09	3.60/4.10	(4.46)/4.71 Max1%S	3.67	-	3.63/4.13

Period Ending	Boston			Philadelphia						Norfolk		
	No. 4	No. 5	No. 6	No. 4		No. 5		No. 6		No.4	No.5	No.6
	Reg.	Reg.	NSG	Reg.	Max 0.7%S	Reg.	Max 1%S	NSG	Max 1%S	Reg.	Reg.	NSG
12/68	3.53	3.25	2.32	3.53	-	3.27	-	2.30	3.07	3.28	2.89	2.29
6/69	3.53	3.05	2.32	3.40	-	3.16	-	2.30	3.07	3.16	2.83	2.29
12/69	3.57	2.91	2.32	3.29	-	3.03	-	2.30	-	3.11	2.84	2.29
3/70	3.38	2.91	2.14	3.29	-	3.03	-	2.22	-	3.11	2.84	2.03
5/70	3.50	3.24	2.35	-	3.61	-	3.29	2.89	-	3.35	3.08	2.27
7/20/70	3.77	3.51	2.65	-	3.92	-	3.72	-	3.15	3.71	3.44	2.63
8/31/70	4.12	3.86	3.00	-	4.27	-	4.07	-	3.50	4.06	3.89	3.08
9/28/70	4.12/4.62	3.86/4.36	3.00/3.50	-	4.27	-	4.07/4.31	-	3.60/4.10	4.06	3.89	3.08

Period Ending	Providence			Wilmington, N.C.			Savannah			New Haven		
	No. 4	No. 5	No. 6	No. 4	No. 5	No. 6	No. 4	No. 5	No. 6	No. 4	No. 5	No. 6
	Reg.	Reg.	NSG	Reg.	Reg.	NSG	Reg.	Reg.	NSG	Reg.	-	NSG
12/68	3.34	3.21	2.40	3.43	3.10	2.28	3.90	3.04	2.32	3.60	-	2.39
6/69	3.34	3.21	2.40	3.43	3.10	2.28	3.90	3.04	2.32	3.60	-	2.39
12/69	3.40	3.24	2.40	3.40	2.98	2.28	3.90	3.04	2.32	3.60	-	2.39
3/70	3.40	3.24	2.40	3.40	2.98	2.28	3.90	3.04	2.32	3.60	-	2.39
5/70	3.55	3.28	2.35	3.40	2.97	2.41	3.90	3.04	2.35	3.77	-	2.39
7/20/70	3.81	3.51	2.61	3.71	3.44	2.63	3.90	3.44	2.69	3.77	-	2.80
8/31/70	4.16	3.86	2.96	4.06	3.89	3.08	4.25	3.79	3.08	4.12	-	2.96
9/28/70	4.16	3.86	2.96/3.46	4.06	3.89	3.08	4.25	3.89	3.08	4.12	-	2.96/3.46

TABLE 8 (Cont'd)

East Coast Ports

Period Ending	Portland No. 4 Reg.	Portland No. 5 Reg.	Portland No. 6 NSG	Charleston No. 4 Reg.	Charleston No. 5 Reg.	Charleston No. 6 Reg.	Miami No. 4 -	Miami No. 5 -	Miami No. 6 NSG
12/68	-	3.23	2.41	-	2.96	2.34	-	-	2.33
6/69	-	3.23	2.41	-	2.96	2.34	-	-	2.33
12/69	-	3.08	2.44	-	2.96	2.34	-	-	2.33
3/70	-	3.08	2.54	-	2.96	2.34	-	-	2.33
5/70	-	3.28	2.82	-	2.96	2.38	-	-	2.33
7/20/70	-	3.53	3.09	-	3.44	2.63	-	-	2.66
8/31/70	4.16	3.88	3.54	4.06	3.89	3.08	-	-	3.05
9/28/70	4.16	3.88	3.54	4.06	3.89	3.08	-	-	3.05

Gulf Ports

Period Ending	Baton Rouge No. 4 -	Baton Rouge No. 5 Reg.	Baton Rouge No. 6 NSG	New Orleans No. 4 -	New Orleans No. 5 Reg.	New Orleans No. 6 NSG	Houston No. 6 NSG	Jacksonville No. 6 NSG	Tampa No. 6 NSG	Port Everglades No. 6 NSG
12/68	-	2.83	2.30	-	2.83	2.30	2.15	2.32	2.32	2.30
6/69	-	2.83	2.30	-	2.83	2.30	2.15	2.32	2.32	2.30
12/69	-	2.83	2.30	-	2.83	2.30	2.15	2.32	2.32	2.30
3/70	-	2.83	2.30	-	2.83	2.30	2.02	2.32	2.32	2.30
5/70	-	2.83	2.30	-	2.83	2.30	2.24	2.35	2.33	2.33
7/20/70	-	3.05	2.55	-	3.08	2.55	2.52	2.69	2.47	2.63
8/31/70	-	3.40	2.90	-	3.43	2.90	3.05	3.07	3.08	3.05
9/28/70	-	3.40	3.17	-	3.43	3.17	3.05	3.07	3.08	3.05

PAD Districts 1 & 2 (Inland)

Period Ending	Albany No. 4 Reg.	Albany No. 6 NSG	Buffalo No. 5 Max 1%S	Buffalo No. 6 Max 1%S	Buffalo No. 6 NSG	Detroit No. 5 Max 1%S	Detroit No. 5 NSG	Detroit No. 6 Max 1%S	Detroit No. 6 NSG	Toledo No. 5 NSG	Toledo No. 6 NSG
12/68	3.67	2.38	3.70	3.42	3.17	3.72	3.61	3.51	3.40	3.78	3.57
6/69	3.67	2.38	3.70	3.42	3.17	3.72	3.61	3.51	3.40	3.78	3.57
12/69	3.67	2.38	3.70	3.42	3.17	3.72	3.61	3.51	3.40	3.78	3.57
3/70	3.67	2.44	3.70	3.42	3.17	3.72	3.61	3.51	3.40	3.78	3.57
5/70	3.67	2.44	3.70	3.42	3.17	3.72	3.61	3.51	3.40	3.78	3.57
7/20/70	3.94	2.94	3.70	3.42	3.17	3.72	3.61	3.51	3.40	3.99	3.78
8/31/70	4.29	3.32	4.20(NSG)	-	3.88	4.20	4.10	3.88	3.78	4.10	3.78
9/28/70	4.29	3.32/3.82	4.20(NSG)	-	3.88	4.41	4.30	4.10	3.99	-	-

TABLE 8 (Cont'd)

Period Ending	PAD Districts 1 & 2 (Inland)								PAD Dist. 3	
	Chicago Area					Minneapolis St. Paul		Oklahoma	Arkansas	
	No. 5		No. 6			No. 5	No. 6	No. 6	No. 5	No. 6
	Low-Sul	Hi-Sul	Max 0.6%S	Max 1%S	NSG	Hi-Sul	Hi-Sul	Reg.	Reg.	NSG
12/68	3.89	3.68	3.57	3.36	3.15	3.89	3.57	1.65	2.50	2.35
6/69	3.89	3.57	3.47	3.31	3.05	3.89	3.57	1.70	2.50	2.35
12/69	3.96	3.68	3.65	3.44	3.15	3.89	3.57	1.70	2.85	2.60
3/70	3.99	3.78	3.68	3.47	3.26	3.99	3.57	2.00	2.85	2.60
5/70	4.12	3.91	3.95	3.55	3.39	3.99	3.57	2.00	2.85	2.60
7/20/70	4.20	3.99	4.10	3.89	3.68	4.20	3.78	2.62	3.00	2.75
8/31/70	4.41/4.62	4.20/4.41	4.10	3.88/4.10	3.68/3.99	4.62	4.20	2.73	3.25	3.00
9/28/70	4.62	4.41	4.41/4.51	4.30	3.99	4.62	-	2.73	3.25	3.00

NSG = No Sulfur Guarantee
Reg = Regular Grade

Data Source: Platt's Oil Price Handbook, 46th Ed., and
Platt's Oilgram Daily Price Service

Prices shown for 1968 and 1969 periods are average for 6-month period.
3/70 and 5/70 prices are average for month.
7/20, 8/31 and 9/28 prices are daily averages.

Note: A price range is indicated where two values are shown.

TABLE 9

POSTED RAILROAD SHIPPING RATES APPLICABLE TO RESIDUAL FUEL OIL SHIPMENT IN TANK CARS OF 15,000 GALLONS AND LARGER

Shipping Radius Miles	Shipping Rates, ¢/100 Lb.			Shipping Rates, ¢/Bbl.		
	Initial 10,500 Gal	Excess Over 10,500 Gal	Overall 15,000 Gal	Initial 10,500 Gal	Excess Over 10,500 Gal	Overall 15,000 Gal
40	33.0	22.4	29.8	102.5	69.7	92.8
50	34.0	23.0	30.7	105.8	71.4	95.3
100	47.5	33.5	43.3	147.4	104.1	134.4
200	56.5	38.5	51.1	175.5	119.7	158.8
300	62.0	40.0	55.4	192.8	124.3	172.2

Shipping Radius Miles	Shipping Rates, ¢/100 Lb-Mile			Shipping Rates, ¢/Bbl-Mile		
	Initial 10,500 Gal	Excess Over 10,500 Gal	Overall 15,000 Gal	Initial 10,500 Gal	Excess Over 10,500 Gal	Overall 15,000 Gal
40	0.825	0.560	0.745	2.562	1.742	2.320
50	0.680	0.460	0.614	2.116	1.428	1.906
100	0.475	0.335	0.433	1.474	1.041	1.344
200	0.282	0.192	0.255	0.877	0.598	0.794
300	0.207	0.133	0.185	0.643	0.414	0.574

Source: Penn Central R.R. Co.

Special contractual shipping rates are applicable under certain conditions. In addition to standard shipping costs, the railroads also apply an import charge of 12¢/100 lb. if the oil is pumped directly from the water transport vessel into the railroad tank car.

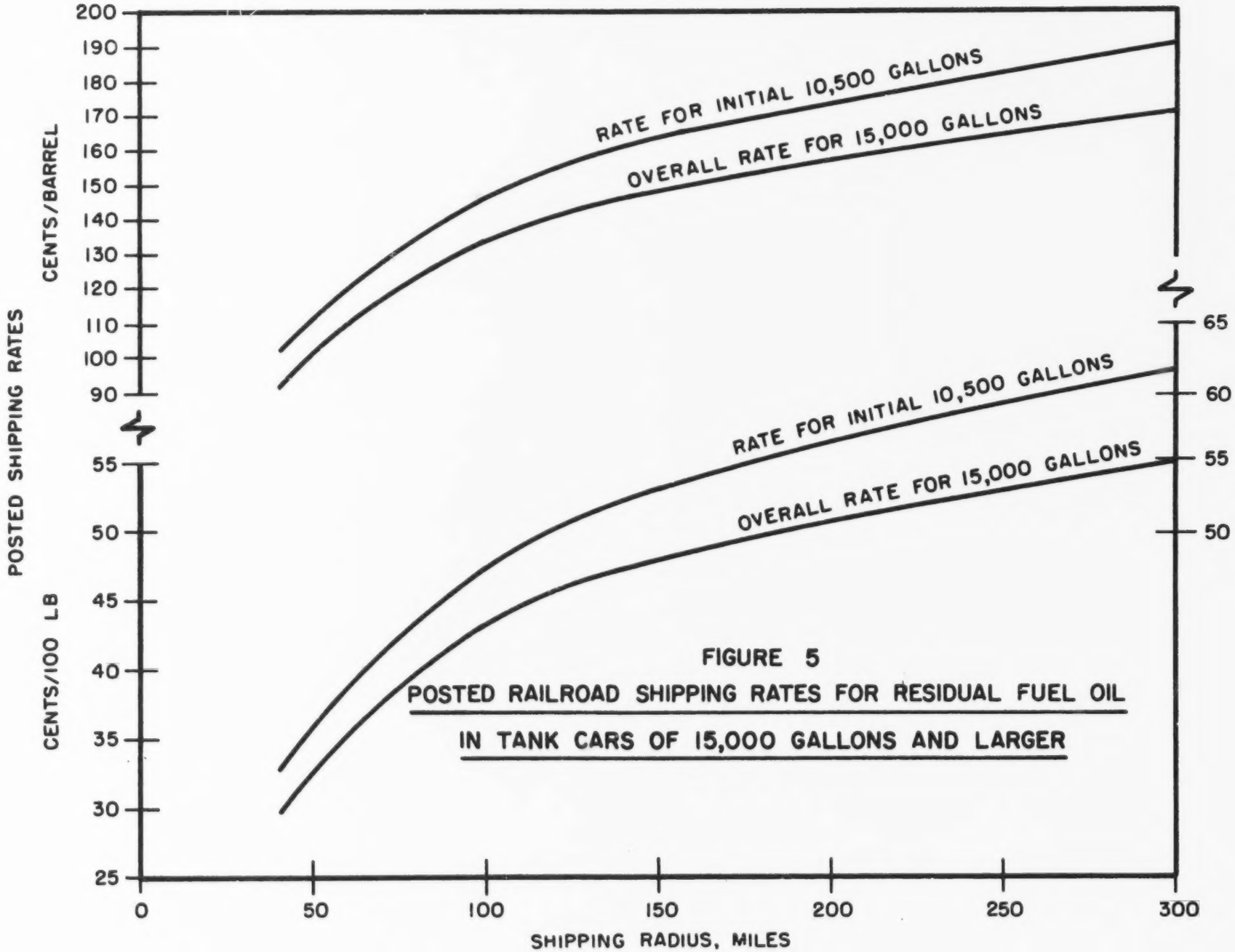


FIGURE 5

POSTED RAILROAD SHIPPING RATES FOR RESIDUAL FUEL OIL

IN TANK CARS OF 15,000 GALLONS AND LARGER

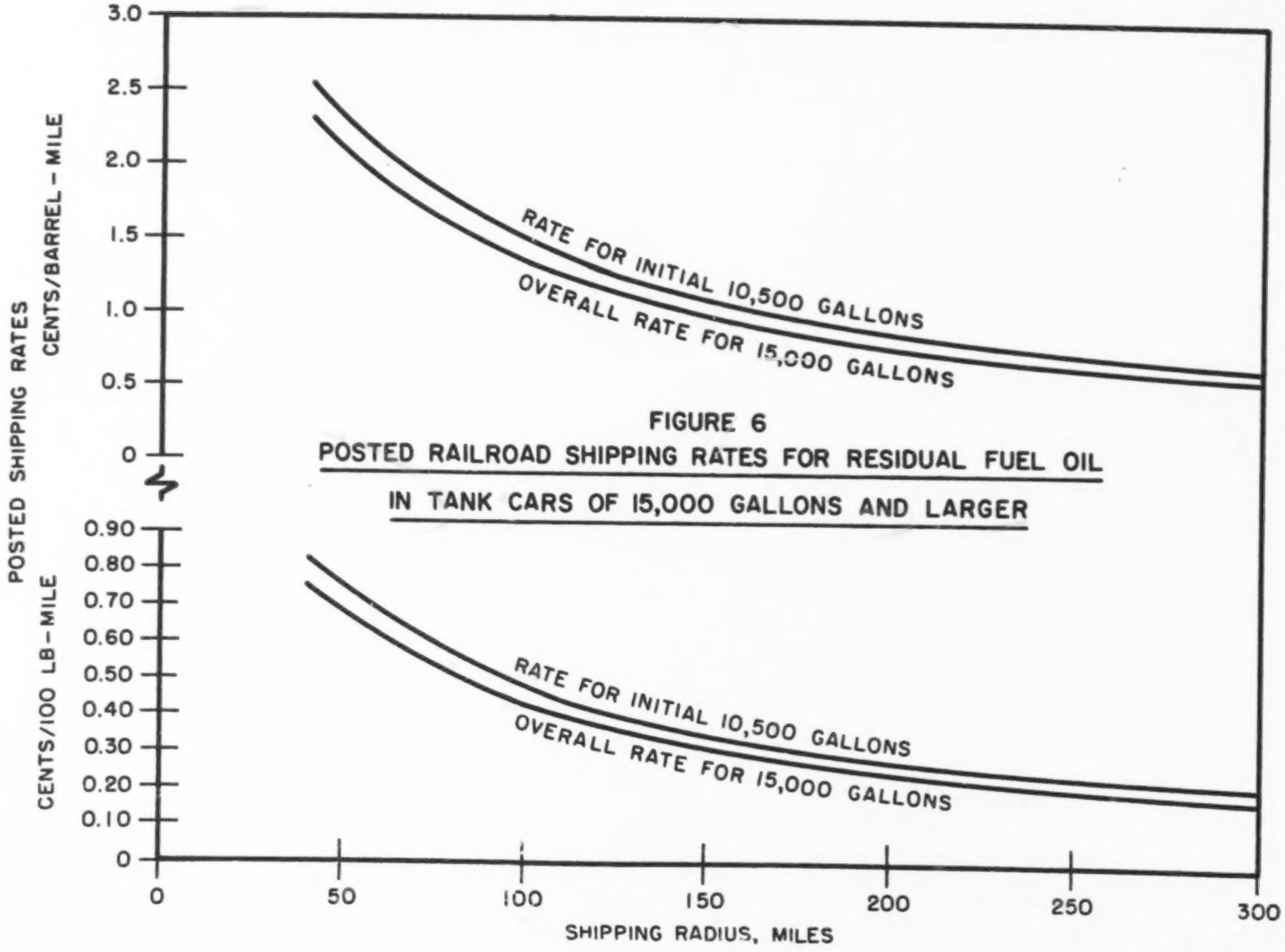


FIGURE 6

POSTED RAILROAD SHIPPING RATES FOR RESIDUAL FUEL OIL IN TANK CARS OF 15,000 GALLONS AND LARGER

TABLE 10

FUEL OIL SPECIFICATIONS

Test	ASTM Method	ASTM D396 Requirements No.1 FO Min/Max	No.2 FO Min/Max	No.4 FO Min/Max	No.5FO(L) Min/Max	No.5FO(H) Min/Max	No.6 FO Min/Max
Gravity, °API	D287	35/-	30/-	-	-	-	-
Flash Point, Pensky-Martens Closed Tester, °F	D93	100/-[1]	100/-	130/-	130/-	130/-	150/-
Viscosity, Kinematic 100°F Centistokes	D445	1.4/2.2	2.0/3.6	5.8/26.4	32/65	75/162	-
Viscosity, Saybolt Furol 122°F, Seconds	D88	-	-	-	-	23/40	45/300
Pour Point, °F	D97	-/0	-/20	-/20	-	-	-
Sulfur Content, Wt. %	D129	-/0.5	-/0.7	-	-	-	-
Ramsbottom Carbon Res. on 10% Residue, Wt. %	D524	-/0.15	-/0.35	-	-	-	-
Corrosion - 3 Hours at 122°F, No.	D130	-/3	-	-	-	-	-
Water and Sediment, Vol. %	D1796	-/Trace	-/0.10	-/0.50	-/1.00	-/1.00	-
Sediment by Extraction, Wt. %	D473	-	-	-	-	-	-/0.50
Ash, Wt. %	D482	-	-	-/0.10	-/0.10	-/0.10	-
Distillation Test, on Volume Recovered Basis	D86						
Initial Boiling Point, °F.		-	-	-	-	-	-
10% Recovery, °F.		-/420	-/440	-	-	-	-
50% Recovery, °F.		-	-	-	-	-	-
90% Recovery, °F.		-/550	540/640	-	-	-	-
End Point, °F.		-	-	-	-	-	-

[1] Tag Closed Tester, D56

Data compiled from USBM Mineral Industry Surveys, Petroleum Products Survey No. 61

TABLE 11

SALES OF RESIDUAL FUEL OIL BY END USE IN THE UNITED STATES
1964-1969

Use	(1000 Barrels)					
	1964	1965	1966	1967	1968	1969
Heating	126,215	156,254	167,471	175,990	174,326	178,095
Industrial (Excluding Oil Co.)	157,176	140,602	141,050	131,819	135,664	130,654
Oil Company	43,098	34,354	35,177	37,880	39,329	36,559
Electric Utility Co.	97,595	114,884	140,642	158,417	184,956	247,634
Railroads	5,350	4,001	3,792	5,494	4,296	3,381
Vessels	83,024	73,639	73,641	80,680	87,575	85,581
Military	35,568	40,380	41,861	40,465	34,990	31,750
All Other	8,606	10,004	10,338	8,794	8,348	8,875
Total	556,632	574,118	613,972	639,539	669,484	722,529

Use	(% of Total)					
	1964	1965	1966	1967	1968	1969
Heating	22.67	27.22	27.28	27.52	26.04	24.65
Industrial (Excluding Oil Co.)	28.24	24.49	22.97	20.61	20.26	18.08
Oil Company	7.74	5.98	5.73	5.92	5.87	5.06
Electric Utility Co.	17.54	20.01	22.91	24.77	27.63	34.27
Railroads	0.96	0.70	0.62	0.86	0.64	0.47
Vessels	14.91	12.83	11.99	12.62	13.08	11.84
Military	6.39	7.03	6.82	6.33	5.23	4.39
All Other	1.55	1.74	1.68	1.37	1.25	1.24
Total	100	100	100	100	100	100

Source: Mineral Industry Surveys, U.S.B.M., Fuel Oil Sales, Annual

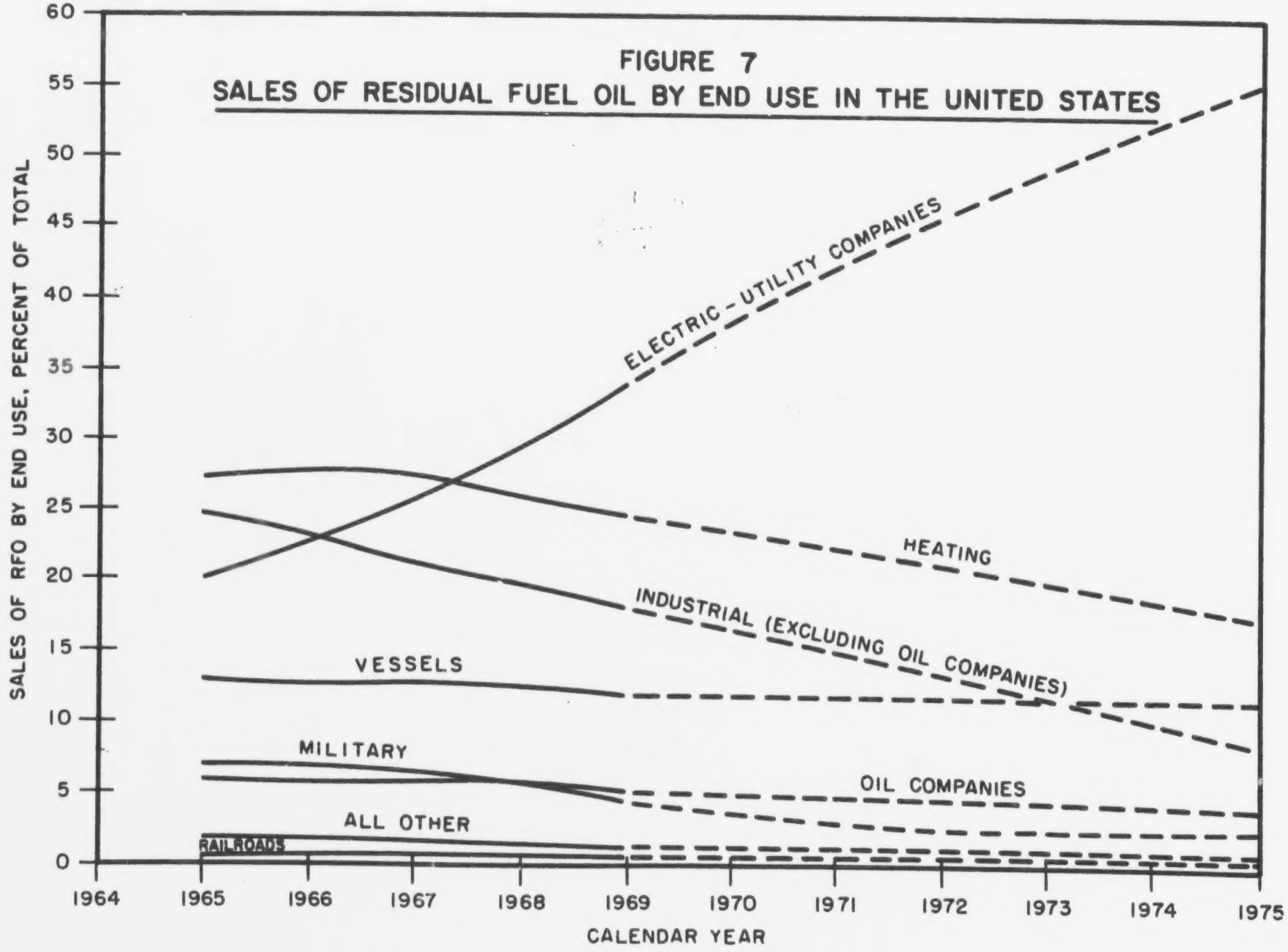
TABLE 12

PROJECTED SALES OF RESIDUAL FUEL OIL BY END USE IN THE UNITED STATES
1970-1975

Use	(1000 Barrels) 1970	1971	1972	1973	1974	1975
Heating	190,000	202,000	212,000	220,000	225,000	227,000
Industrial (Excluding Oil Co.)	133,000	134,400	134,000	129,000	122,000	110,000
Oil Company	39,000	42,000	44,000	45,000	47,000	48,000
Electric Utility Co.	309,000	380,000	463,000	544,000	627,000	718,000
Railroads	3,000	3,600	3,000	3,300	3,600	4,000
Vessels	95,000	106,000	118,000	128,000	140,000	149,000
Military	30,000	28,000	24,000	26,700	29,400	31,000
All Other	9,000	9,000	9,000	10,000	11,000	12,000
Total	808,000	905,000	1,007,000	1,106,000	1,205,000	1,299,000

Use	(% of Total) 1970	1971	1972	1973	1974	1975
Heating	23.5	22.3	21.1	19.9	18.7	17.5
Industrial (Excluding Oil Co.)	16.5	14.9	13.3	11.7	10.1	8.5
Oil Company	4.8	4.6	4.4	4.1	3.9	3.7
Electric Utility Co.	38.2	42.0	45.9	49.1	52.1	55.2
Railroads	0.4	0.4	0.3	0.3	0.3	0.3
Vessels	11.8	11.7	11.7	11.6	11.6	11.5
Military	3.7	3.1	2.4	2.4	2.4	2.4
All Other	1.1	1.0	0.9	0.9	0.9	0.9
Total	100	100	100	100	100	100

FIGURE 7
SALES OF RESIDUAL FUEL OIL BY END USE IN THE UNITED STATES



period 1965-1975.

Tables 13 and 14 present total sales of distillate fuel oil in the United States by end use for the years 1964 through 1975. Projected sales for the period 1970-1975 are based on the extrapolated total sales volume shown in Figure 8 and the trend of end use as a percent of the total, for the period 1964-1969, from Table 13. Figure 9 shows the actual and projected sales of DFO, as a percentage of total sales, for each use category for the period 1965-1975.

Table 15 presents overall United States RFO statistics for the period 1960-May 1970. Included are total crude runs to stills, total RFO production, RFO production as volume percent of crude charged, and RFO imports. The percent of total RFO used is broken down into domestic and foreign import components, thus showing the growing dependence of the United States on foreign sources for RFO. The importance of RFO imports is illustrated by the following: in 1960 the split was 58.8% domestic and 41.2% imported whereas it was 30.3% domestic and 69.7% imported for the period of January to May 1970.

Table 16 presents RFO statistics for PAD district 1 for the period 1965 through May 1970. It can be seen that domestic production including imports from PAD districts 3 and 5 remained relatively static while foreign imports increased steadily. The percent of the total RFO imported into the United States and consumed in PAD 1 increased from 92.3% in 1965 to 96.8% in 1970. Thus, it appears that the east coast area (PAD 1) has become increasingly dependent on imported RFO. In 1965 imported RFO represented 81.8% of total consumption whereas by 1970 this had increased to 90.7%.

TABLE 13

SALES OF DISTILLATE FUEL OIL BY END USE IN THE UNITED STATES 1964-1969

Use	(1000 Barrels)					
	1964	1965	1966	1967	1968	1969
Heating	451,860	475,992	472,778	501,026	510,682	511,768
Industrial (Excluding Oil Co.)	36,007	42,484	47,108	44,997	45,795	42,456
Oil Company	10,576	10,430	10,485	8,997	9,975	13,867
Electric Utility Co.	3,849	3,661	3,612	2,858	8,509	12,158
Railroads	88,198	86,436	89,104	88,688	84,030	86,429
Vessels	16,001	15,532	16,642	17,478	18,235	18,877
Military	13,609	14,953	16,303	17,325	12,593	13,958
On-Highway Diesel	76,131	73,776	81,516	(1)	124,082	138,814
Off-Highway Diesel	41,403	50,346	54,260	(1)	47,691	49,439
All Other	9,917	13,281	17,905	147,831	11,508	12,534
Total	747,551	786,891	809,713	829,200	873,100	900,300

Use	(% of Total)					
	1964	1965	1966	1967	1968	1969
Heating	60.4	60.5	58.4	60.4	58.5	56.8
Industrial (Excluding Oil Co.)	4.8	5.4	5.8	5.4	5.2	4.7
Oil Company	1.4	1.3	1.3	1.1	1.1	1.5
Electric Utility Co.	0.5	0.5	0.4	0.3	1.0	1.4
Railroads	11.8	11.0	11.0	10.7	9.6	9.6
Vessels	2.1	2.0	2.0	2.1	2.1	2.1
Military	1.8	1.9	2.0	2.1	1.4	1.5
On-Highway Diesel	10.2	9.4	10.1	(1)	14.2	15.4
Off-Highway Diesel	5.5	6.4	6.7	(1)	5.5	5.5
All Other	1.5	1.6	2.3	17.9	1.4	1.5
Total	100	100	100	100	100	100

Source: Mineral Industry Surveys, U.S.B.M., Fuel Oil Sales, Annual (1) Included in All Other

TABLE 14

PROJECTED SALES OF DISTILLATE FUEL OIL BY END USE IN THE UNITED STATES
1970-1975

Use	(1000 Barrels) 1970	1971	1972	1973	1974	1975
Heating	522,000	532,000	542,000	553,000	561,000	570,000
Industrial (Excluding Oil Co.)	48,000	50,000	52,000	53,000	55,000	56,000
Oil Company	12,000	12,000	13,000	13,000	14,000	14,000
Electric Utility Co.	14,000	15,000	17,000	18,000	20,000	22,000
Railroads	86,000	85,000	83,000	82,000	80,000	78,000
Vessels	20,000	20,000	21,000	21,000	22,000	23,000
Military	14,000	14,000	14,000	14,000	14,000	14,000
On-Highway Diesel	153,000	168,000	182,000	199,000	214,000	232,000
Off-Highway Diesel	51,000	53,000	55,000	56,000	58,000	60,000
All Other	11,000	12,000	13,000	13,000	15,000	15,000
Total	931,000	961,000	992,000	1,022,000	1,053,000	1,084,000

Use	(% of Total) 1970	1971	1972	1973	1974	1975
Heating	56.1	55.4	54.7	54.0	53.3	52.6
Industrial (Excluding Oil Co.)	5.2	5.2	5.2	5.2	5.2	5.2
Oil Company	1.3	1.3	1.3	1.3	1.3	1.3
Electric Utility Co.	1.5	1.6	1.7	1.8	1.9	2.0
Railroads	9.2	8.8	8.4	8.0	7.6	7.2
Vessels	2.1	2.1	2.1	2.1	2.1	2.1
Military	1.5	1.5	1.4	1.4	1.3	1.3
On-Highway Diesel	16.4	17.4	18.4	19.4	20.4	21.4
Off-Highway Diesel	5.5	5.5	5.5	5.5	5.5	5.5
All Other	1.2	1.2	1.3	1.3	1.4	1.4
Total	100	100	100	100	100	100

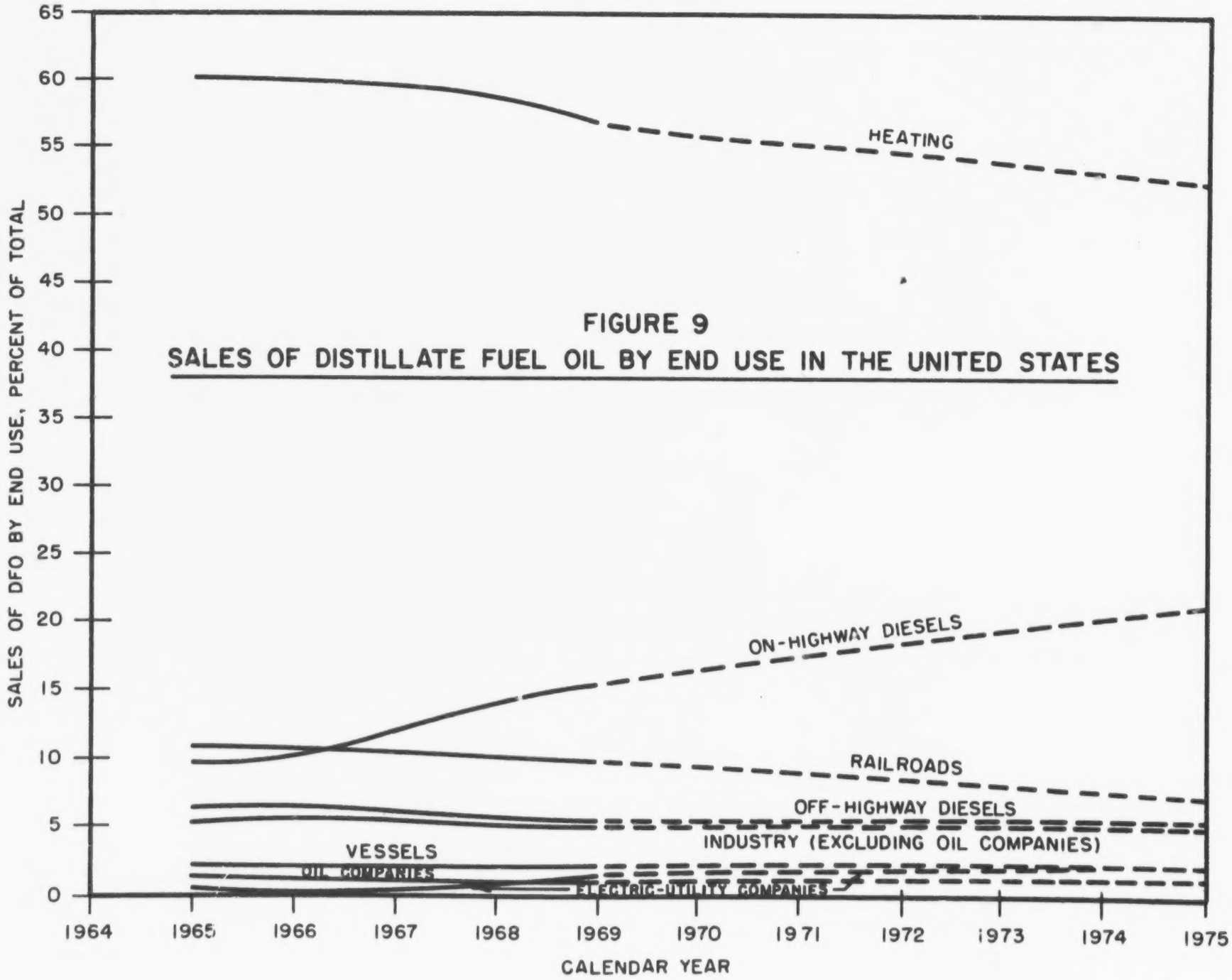


FIGURE 9

SALES OF DISTILLATE FUEL OIL BY END USE IN THE UNITED STATES

FIGURE 8

TOTAL SALES OF DISTILLATE FUEL OIL IN THE UNITED STATES

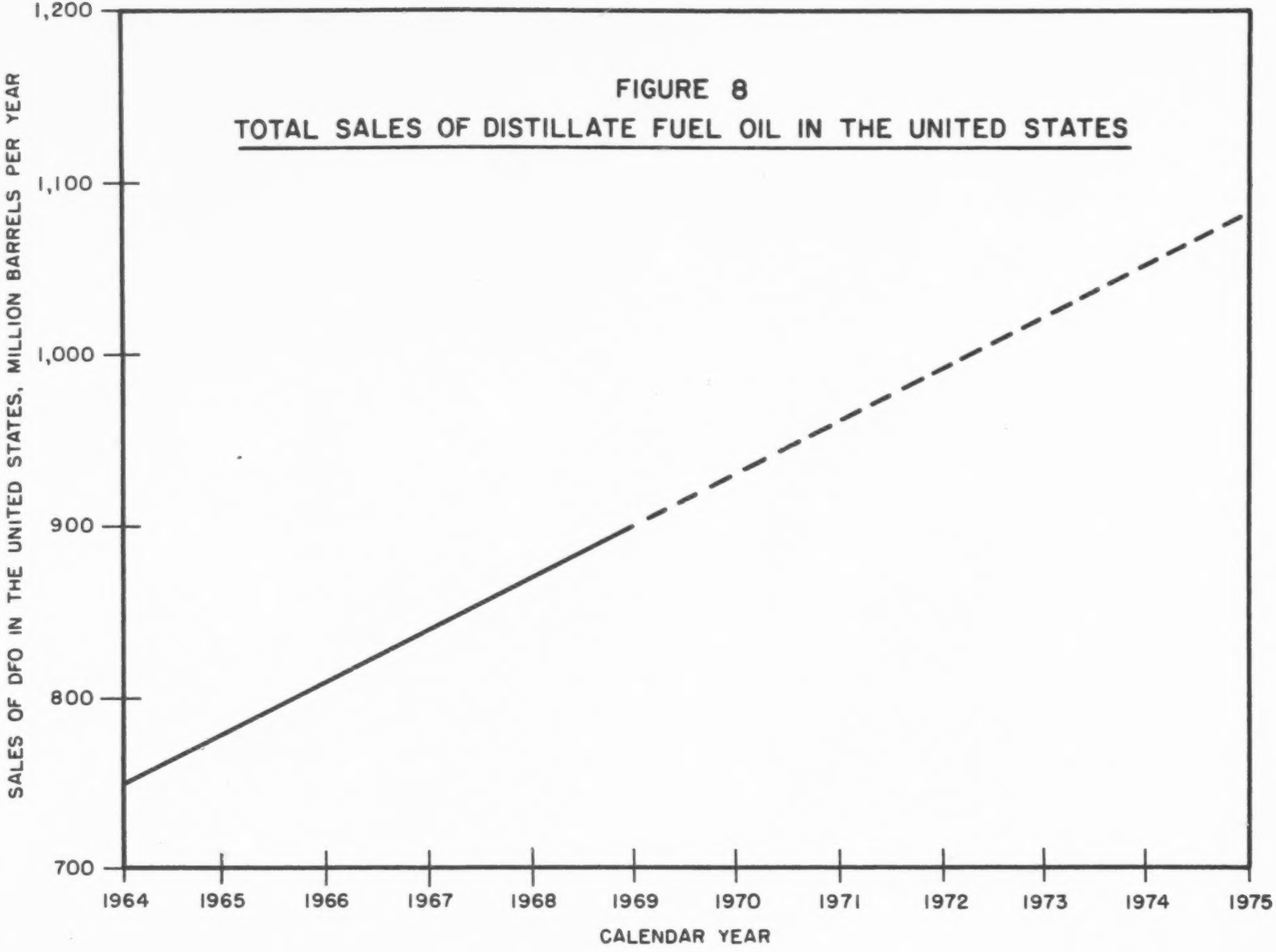


TABLE 15

DOMESTIC AND IMPORTED RESIDUAL FUEL OIL STATISTICS FOR OVERALL UNITED STATES
1960 THRU MAY 1970

(All Quantities in 1000 Barrels)

Year	Total Crude Runs to Stills	Total RFO Production	Vol. % RFO on Crude	Imported RFO	Total RFO	% of Total RFO	
						Domestic	Imported
1960	2,952,539	332,147	11.25	233,208	565,355	58.75	41.25
1961	2,987,158	315,577	10.56	243,268	558,845	56.47	43.53
1962	3,069,631	295,679	9.63	264,314	559,993	52.80	47.20
1963	3,170,652	275,910	8.70	272,753	548,663	50.29	49.71
1964	3,223,329	266,825	8.28	295,771	562,596	47.43	52.57
1965	3,330,842	268,567	8.06	345,187	613,754	43.76	56.24
1966	3,447,193	263,961	7.66	376,795	640,756	41.20	58.80
1967	3,582,594	275,956	7.70	395,939	671,895	41.07	58.93
1968	3,774,360	275,814	7.30	409,928	685,742	40.22	59.78
1969	3,880,098	265,906	6.85	461,611	727,517	36.55	63.45
1st Quarter 1970	977,576	73,549	7.52	171,015	244,564	30.07	69.93
Thru May 1970	1,619,925	111,054	6.85	255,144	366,198	30.33	69.67

Source: API, Petroleum Facts & Figures
USBM, Mineral Industry Surveys, Petroleum Statements

TABLE 16

DOMESTIC AND IMPORTED RESIDUAL FUEL OIL STATISTICS FOR PAD 1 DISTRICT
1965 THRU MAY 1970

(All Quantities in 1000 Barrels)

Year	Domestic RFO			Foreign Import	Combined Total RFO	% of U.S. Total RFO Used in PAD 1		
	Produced in PAD 1	Imported From PAD 3 & 5	Total Domestic			Domestic	Foreign	Combined
1965	35,782	35,081	70,863	318,634	389,497	26.38	92.31	63.46
1966	39,446	31,663	71,109	357,907	429,016	26.94	94.99	66.95
1967	40,941	30,925	71,866	383,260	455,126	26.04	96.80	67.74
1968	40,829	35,415	76,244	394,528	470,772	27.64	96.24	68.65
1969	42,257	27,354	69,611	440,983	510,594	26.18	95.50	70.18
1st Quarter 1970	10,710	6,183	16,893	166,644	183,537	22.97	97.44	75.05
Thru May 1970	16,082	9,138	25,220	246,902	272,122	22.71	96.77	74.31

Source: API, Petroleum Facts & Figures
USBM, Mineral Industry Surveys, Petroleum Statements

V. RESIDUAL FUEL OIL SITUATION--PRESENT AND FUTURE

The phase 2 objectives of this task are to estimate the RFO production capability of domestic refineries and those foreign refineries which export the bulk of their production to the United States. The estimates of production capability are made for the following three cases:

a. RFO production capability of existing refineries at current sulfur levels.

b. RFO production capability of existing refineries at low sulfur levels.

c. RFO production capability at low sulfur levels of future refineries modified by the addition of hydrotreating facilities.

A further objective is to estimate the incremental and capital investment costs of producing low sulfur RFO by the addition of hydrotreating facilities as in case c. In all of the above cases the assumption is made that no trade barriers or import quotas exist. This assumption is essentially true at present in PAD district 1 (Eastern Seaboard) which consumes roughly 95% of all RFO imported into the United States. There are no restrictions pertaining to the import of RFO into District 1 but there are restrictions on the importation of crude oil and restrictions prohibiting the reprocessing of RFO except by special permit.

Tables 17 through 23 and Figures 10 through 22 of this report are applicable to phase 2 of the task specifications. A brief discussion of the individual items follows.

A. Current and Projected Production of RFO

Table 17 contains refinery throughput and RFO production statistics for the Caribbean and South American areas which produce RFO primarily for export to the United States. Over the period 1964-69 total RFO production increased by an average of 3.4% per year while RFO production as volume percent on refinery throughput varied between 56.1% and 57.7%. RFO statistics for 1970 have not been published but should show a sizable increase over 1969 partly due to startup of a large refinery in the Bahamas and partly caused by increased production from the South American refineries, the latter being attributed to the large increase in RFO prices on the Eastern Seaboard.

Table 18 presents United States RFO supply and demand statistics for the period 1960 through May 1970. During the period of steadily declining domestic RFO production between 1960 and 1968 the demand for this product increased, on an average, by 2.4% per year. Then in 1969 demand increased by 8% thus reflecting the increasing restrictions on the use of high sulfur fossil fuels along the east coast. The effect of restricting the use of high sulfur fuel became further apparent in 1970 when during the first five months of the year demand increased by 13.7% over the similar period of 1969.

TABLE 17

PRODUCTION STATISTICS FOR REFINERIES PRODUCING RESIDUAL FUEL OILS FOR IMPORT INTO THE UNITED STATES - 1964-1969

(All Quantities in 1000 Barrels)

Year	Location	Refinery Thruput	Residual Fuel Oil Production	% V, RFO On Crude
1969	Netherlands Antilles	311,227	174,716	56.1
	Trinidad	154,770	88,381	57.1
	Venezuela	421,794	255,038	60.5
	Virgin Islands	59,678	28,645	48.0
	Total	947,469	546,780	57.7
1968	NA	296,795	156,444	52.7
	Trin	151,282	85,337	56.4
	Ven	434,033	255,533	58.9
	VI	41,175	20,295	49.3
	Total	923,285	517,609	56.1
1967	NA	304,364	157,473	51.7
	Trin	139,261	75,496	54.2
	Ven	425,518	256,209	60.2
	VI	-	-	-
	Total	869,143	489,177	56.3
1966	NA	287,500	143,455	49.9
	Trin	144,193	79,661	55.2
	Ven	428,395	259,294	60.5
	Total	860,088	482,410	56.1
1965	NA	294,565	161,636	54.9
	Trin	137,643	75,442	54.8
	Ven	429,021	255,670	59.6
	Total	861,229	492,748	57.2
1964	NA	301,970	161,801	53.6
	Trin	127,548	71,287	55.9
	Ven	399,673	233,959	58.5
	Total	829,191	467,047	56.3

Data Source: Bureau of Mines, "International Petroleum Annual"

TABLE 18

U.S. SUPPLY AND DEMAND STATISTICS FOR RESIDUAL FUEL OIL
1960 - MAY 1970

(All Quantities in 1000 Barrels)

Year	Total New Supply			Stocks (End of Year)	Total Demand		
	Domestic Production	Transfer From Crude Oil	Imports		Exports	Domestic Demand	% Change In Demand
1960	332,147	3,948	233,208	44,870	18,495	559,439	-
1961	315,577	3,854	243,268	44,869	14,022	548,678	-1.92
1962	295,679	3,797	264,314	49,996	12,850	545,813	-0.52
1963	275,910	3,305	272,753	47,538	15,281	538,924	-1.26
1964	266,825	3,720	295,771	40,403	18,870	554,581	+2.9
1965	268,567	3,950	345,187	56,214	14,882	587,011	+5.85
1966	263,961	3,551	376,795	61,196	12,879	626,446	+6.72
1967	275,956	3,671	395,939	65,597	21,940	651,885	+4.06
1968	275,814	4,272	409,928	67,359	20,013	668,239	+2.61
1st Quarter 1969	78,335	1,145	133,988	55,188	5,064	218,575	-
Thru May 1969	123,169	1,855	207,042	60,570	7,883	328,972	-
1969	265,906	4,334	461,611	60,395	16,893	721,922	+8.03
1st Quarter 1970	73,549	1,190	171,015	40,320	4,693	259,136	+18.56
Thru May 1970	111,054	1,987	255,144	44,664	7,862	374,054	+13.70

Source: API, Petroleum Facts & Figures
USBM, Mineral Industry Surveys, Petroleum Statements

Table 19 and Figures 10-13 show data on average crude runs to stills, RFO demand and production statistics, and RFO import requirements for the period 1960-1975. Projected statistics for the period 1971-1975 are given for three sulfur levels. The projections for low sulfur RFO production are based on the data of reference 6-a. Demand statistics were projected on the basis of the 1969-1970 growth rates and are possibly somewhat conservative as evidenced by the latest 1970 trend. The low sulfur RFO production rates are applicable after the addition of hydrotreating facilities as described later in section VI-A-3 of this report. The 1971-1975 projected RFO production rates, calculated as volume percent on crude, are based on the long term industry trend of maximizing profits by minimizing RFO production. Figure 11 shows the United States demand for RFO projected through 1975 at growth rates corresponding to different time periods. Figure 12 is a plot of United States RFO production, expressed as volume percent on crude charged, as a function of time projected through 1975 at current sulfur levels and at 1.0% and 0.5% sulfur levels. From this plot it is obvious that if a 0.5% sulfur RFO pool is required, U.S. production will be significantly reduced below that at the current sulfur level.

Tables 20 and 21 tabulate the monthly RFO demand for the periods 1966-1970 and 1971-1975, respectively. The projected demand statistics are based on the projected average daily demand figures from Table 19 and the average ratio of monthly demand to average yearly demand. The wide variation in demand, amounting to 69% from the July minimum to the January maximum, complicates the forecasting of the supply picture since it introduces the

TABLE 19

U.S. SUPPLY AND DEMAND STATISTICS FOR RESIDUAL FUEL OIL
PROJECTED THRU 1975 AT DIFFERENT RFO POOL SULFUR LEVELS

Year	Daily Aver. Crude Runs To Stills (1) MM Bbl/CD	Total RFO Demand (Daily Aver) MM Bbl/CD	RFO Production % V on Crude Charge			RFO Production Daily Aver, MM Bbl/CD			RFO Imports Daily Aver, MM Bbl/CD (Reqd To Meet Demand)		
			Current Sulfur Level	Sulfur 1.0% W	Sulfur 0.5% W	Current Sulfur Level	Sulfur 1.0% W	Sulfur 0.5% W	Current Sulfur Level	Sulfur 1.0% W	Sulfur 0.5% W
1960	8.067	1.528	11.25	-	-	0.907	-	-	0.637	-	-
1961	8.187	1.503	10.56	-	-	0.864	-	-	0.666	-	-
1962	8.412	1.495	9.63	-	-	0.810	-	-	0.724	-	-
1963	8.689	1.477	8.70	-	-	0.756	-	-	0.747	-	-
1964	8.804	1.515	8.28	-	-	0.729	-	-	0.808	-	-
1965	9.125	1.608	8.06	-	-	0.735	-	-	0.946	-	-
1966	9.444	1.716	7.66	-	-	0.723	-	-	1.032	-	-
1967	9.815	1.786	7.70	-	-	0.756	-	-	1.085	-	-
1968	10.312	1.831	7.30	-	-	0.753	-	-	1.123	-	-
1969	10.630	1.978	6.85	-	-	0.728	-	-	1.265	-	-
1970	10.9	2.208	6.70	-	-	0.730	-	-	1.478	-	-
1971	11.5	2.48	6.50	5.87	4.85	0.747	0.675	0.558	1.73	1.81	1.92
1972	12.1	2.75	6.30	5.69	4.71	0.762	0.688	0.570	1.99	2.06	2.18
1973	12.8	3.03	6.10	5.51	4.56	0.781	0.705	0.584	2.25	2.32	2.45
1974	13.5	3.30	5.90	5.33	4.41	0.796	0.719	0.595	2.50	2.58	2.70
1975	14.2	3.56	5.75	5.19	4.30	0.816	0.737	0.611	2.74	2.82	2.95

(1) Annual Statistical Review, Dept. of Statistics, API, April 1970 (1960-1969) and OGJ, April 6, 1970, p. 89 (1970-1975)

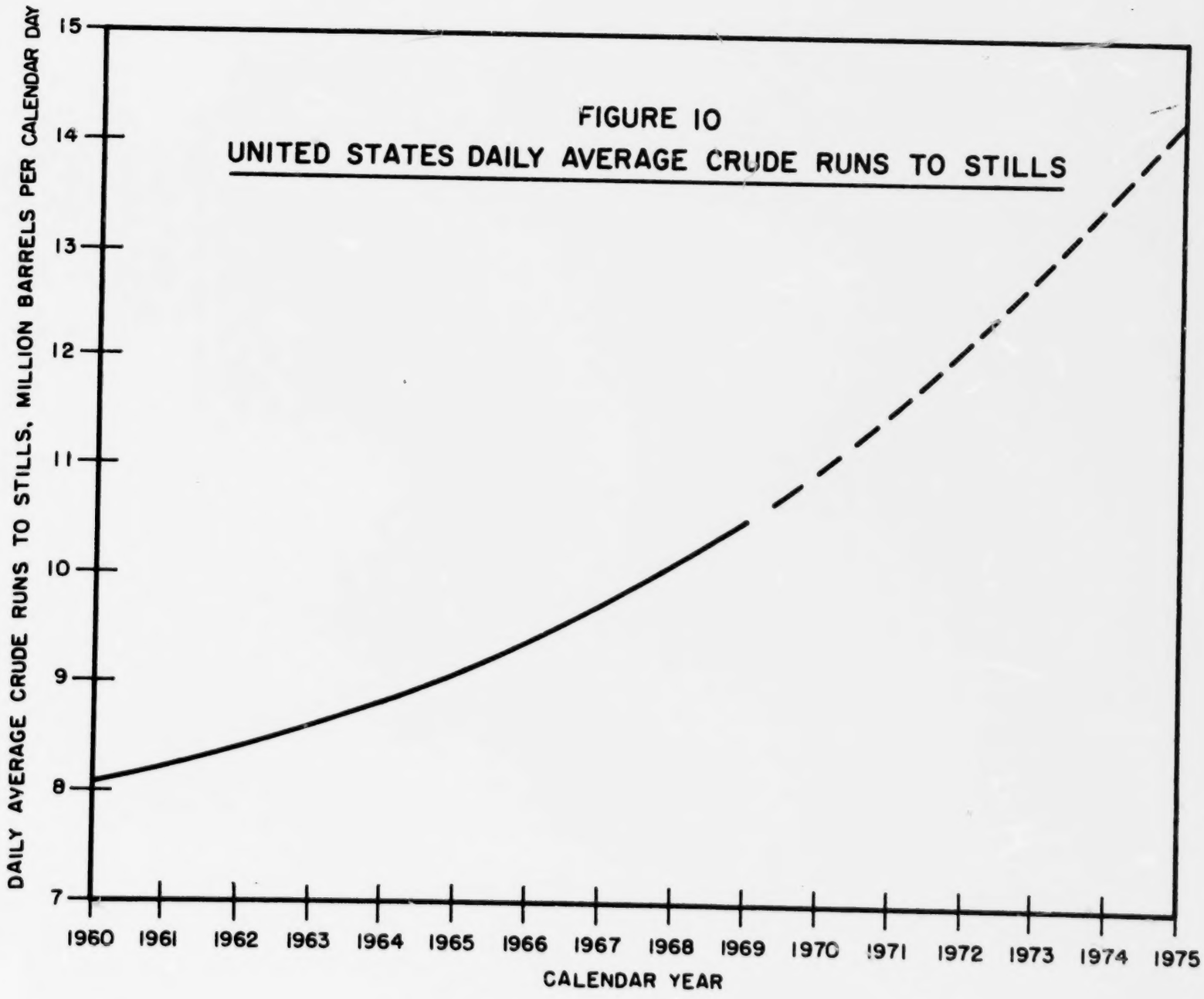
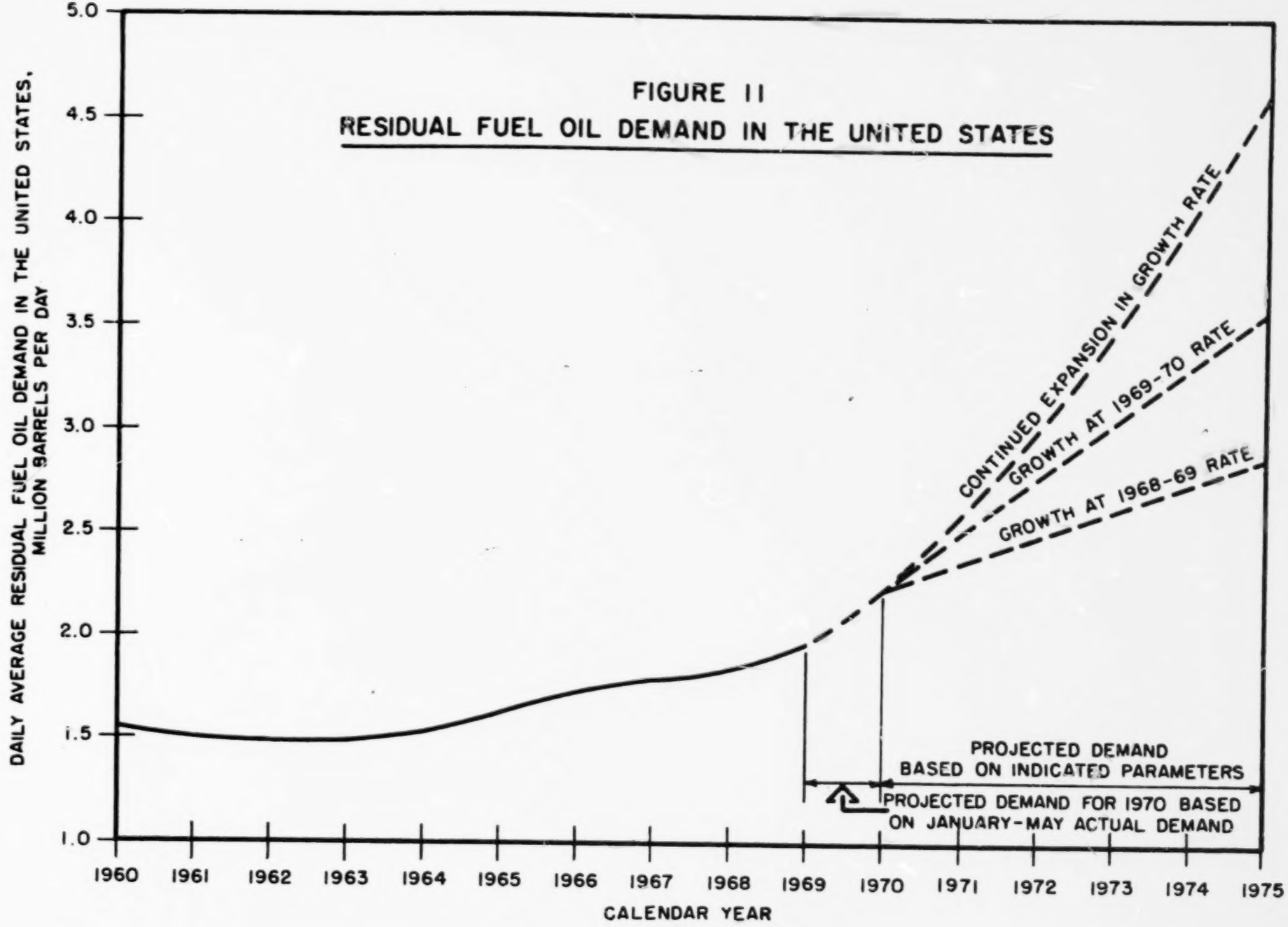


FIGURE 10
UNITED STATES DAILY AVERAGE CRUDE RUNS TO STILLS
DAILY AVERAGE CRUDE RUNS TO STILLS, MILLION BARRELS PER CALENDAR DAY
15
14
13
12
11
10
9
8
7
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
CALENDAR YEAR

FIGURE 11

RESIDUAL FUEL OIL DEMAND IN THE UNITED STATES



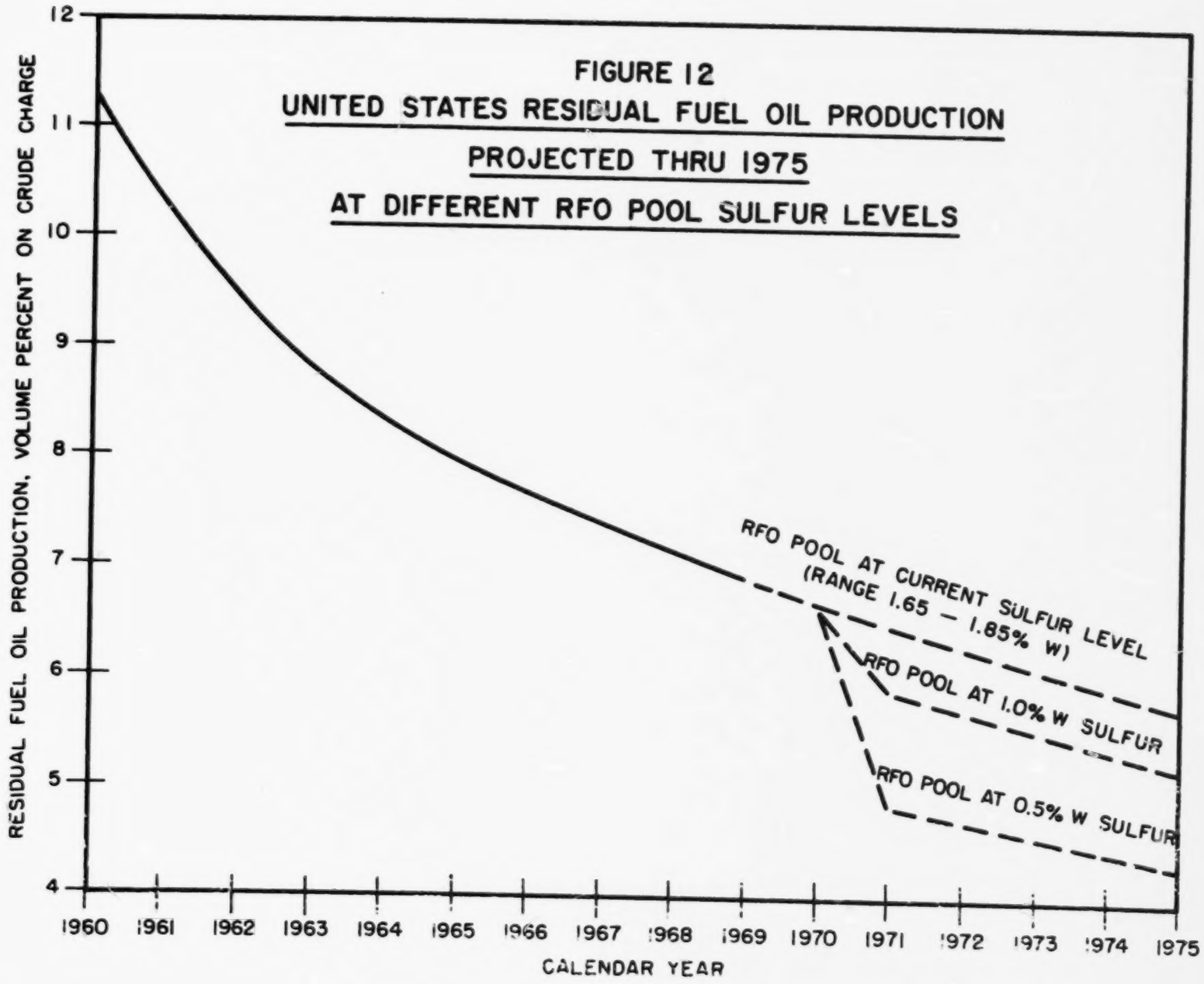


FIGURE 12
UNITED STATES RESIDUAL FUEL OIL PRODUCTION
PROJECTED THRU 1975
AT DIFFERENT RFO POOL SULFUR LEVELS
RESIDUAL FUEL OIL PRODUCTION, VOLUME PERCENT ON CRUDE CHARGE
12
11
10
9
8
7
6
5
4
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
CALENDAR YEAR
RFO POOL AT CURRENT SULFUR LEVEL
(RANGE 1.65 – 1.85% W)
RFO POOL AT 1.0% W SULFUR
RFO POOL AT 0.5% W SULFUR

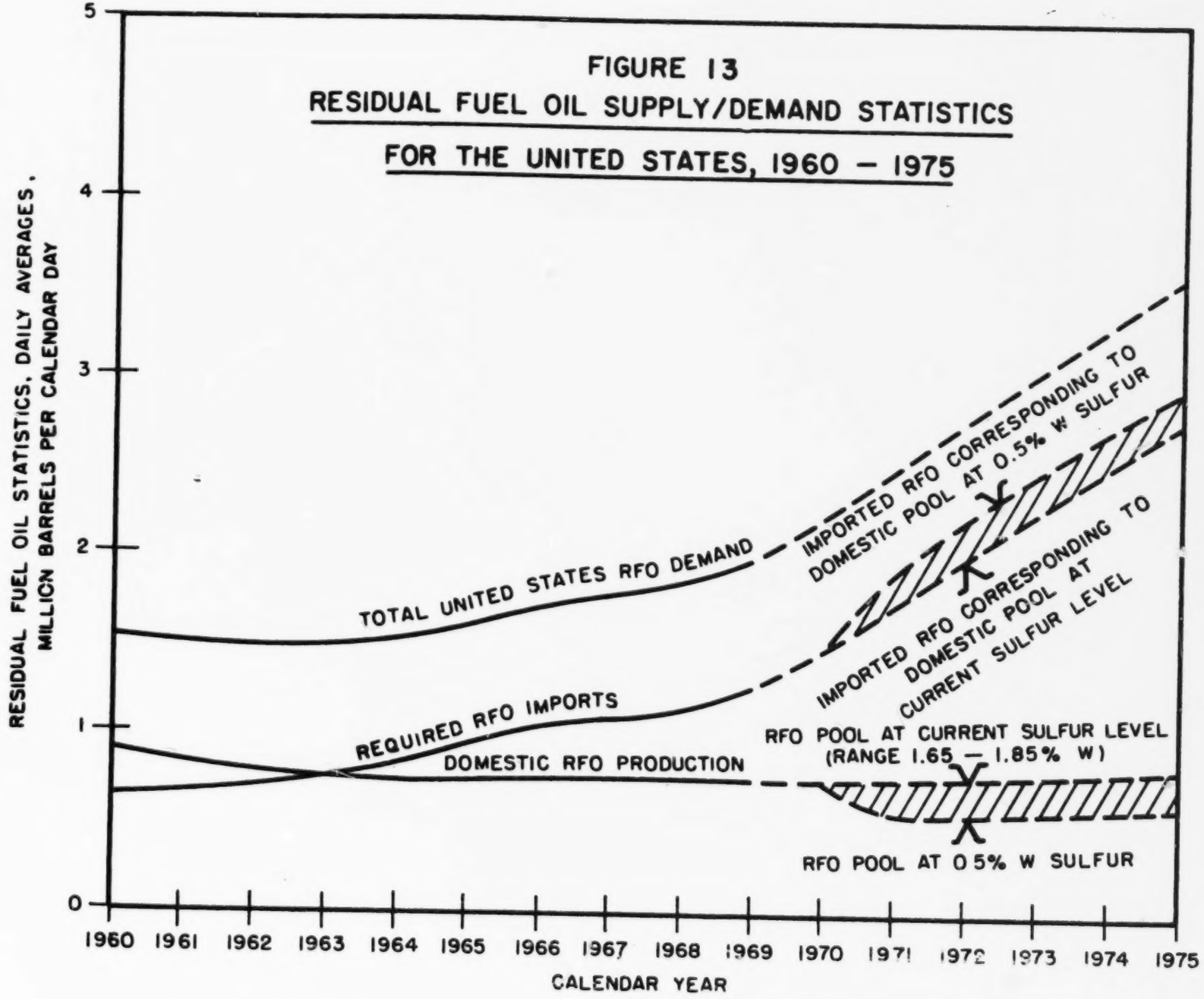


FIGURE 13
RESIDUAL FUEL OIL SUPPLY/DEMAND STATISTICS
FOR THE UNITED STATES, 1960 – 1975
RESIDUAL FUEL OIL STATISTICS, DAILY AVERAGES, MILLION BARRELS PER CALENDAR DAY
5
4
3
2
1
0
TOTAL UNITED STATES RFO DEMAND
IMPORTED RFO CORRESPONDING TO DOMESTIC POOL AT 0.5% W SULFUR
IMPORTED RFO CORRESPONDING TO DOMESTIC POOL AT CURRENT SULFUR LEVEL
REQUIRED RFO IMPORTS
DOMESTIC RFO PRODUCTION
RFO POOL AT CURRENT SULFUR LEVEL (RANGE 1.65 – 1.85% W)
RFO POOL AT 0.5% W SULFUR
1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975
CALENDAR YEAR

TABLE 20

U.S. MONTHLY DEMAND FOR RESIDUAL FUEL OIL (1966-1970)

(All Quantities in 1000 Barrels)

Month	1966 Bbl/CD	1966 Ratio To Aver.	1967 Bbl/CD	1967 Ratio To Aver.	1968 Bbl/CD	1968 Ratio To Aver.	1969 Bbl/CD	1969 Ratio To Aver.	1970 Bbl/CD	1970 Ratio To Aver.	Aver. Ratio
January	2125	1.238	2277	1.275	2675	1.461	2757	1.394	2894	1.311	1.330
February	2309	1.345	2277	1.275	2379	1.299	2481	1.254	2935	1.329	1.300
March	2126	1.239	2201	1.232	2007	1.096	2197	1.111	2815	1.275	1.180
April	1637	0.954	1744	0.976	1672	0.913	1955	0.988	2121	0.960	0.952
May	1394	0.812	1593	0.892	1415	0.773	1670	0.844	1654	0.749	0.810
June	1480	0.862	1502	0.841	1584	0.865	1583	0.800	1848	0.837	0.837
July	1387	0.808	1371	0.768	1476	0.806	1561	0.789	1737	0.787	0.787
August	1459	0.850	1410	0.789	1410	0.770	1655	0.837	1780	0.806	0.806
September	1397	0.814	1343	0.752	1605	0.876	1816	0.918	1841	0.834	0.834
October	1525	0.889	1795	1.005	1641	0.896	1891	0.956	2106	0.954	0.954
November	1765	1.028	1908	1.068	1875	1.024	1851	0.936	2230	1.010	1.010
December	2028	1.182	2037	1.140	2263	1.236	2487	1.257	2650	1.200	1.200
Yearly Aver.	1716	1.000	1786	1.000	1831	1.000	1978	1.000	2208	1.000	1.000

Data Source: USDI, Bureau of Mines, Petroleum Statement, Monthly (Jan. 1966-May 1970)

TABLE 21

U.S. MONTHLY DEMAND FOR RESIDUAL FUEL OIL PROJECTED THROUGH 1975

(All Quantities in 1000 Barrels)

Month	1971		1972		1973		1974		1975		Aver.
	Bbl/CD	Ratio	Bbl/CD	Ratio	Bbl/CD	Ratio	Bbl/CD	Ratio	Bbl/CD	Ratio	Ratio
January	3298	1.330	3657	1.330	4030	1.330	4389	1.330	4735	1.330	1.330
February	3224	1.300	3575	1.300	3939	1.300	4290	1.300	4628	1.300	1.300
March	2926	1.180	3245	1.180	3575	1.180	3894	1.180	4200	1.180	1.180
April	2360	0.952	2618	0.952	2884	0.952	3146	0.952	3389	0.952	0.952
May	2008	0.810	2227	0.810	2454	0.810	2673	0.810	2883	0.810	0.810
June	2075	0.837	2301	0.837	2536	0.837	2762	0.837	2980	0.837	0.837
July	1951	0.787	2164	0.787	2385	0.787	2597	0.787	2801	0.787	0.787
August	1998	0.806	2216	0.806	2442	0.806	2660	0.806	2869	0.806	0.806
September	2068	0.834	2293	0.834	2527	0.834	2752	0.834	2969	0.834	0.834
October	2365	0.954	2623	0.954	2890	0.954	3148	0.959	3396	0.959	0.954
November	2504	1.010	2777	1.010	3060	1.010	3333	1.010	3596	1.010	1.010
December	2976	1.200	3300	1.200	3636	1.200	3960	1.200	4272	1.200	1.200
Yearly Aver.	2480	1.000	2750	1.000	3030	1.000	3300	1.000	3560	1.000	1.000

factors of shipping availability and storage capacity. Figure 14 illustrates the variation in RFO monthly demand for the period 1966-75.

Table 22 (Parts 1 & 2) includes domestic RFO demand and production, required imports to meet domestic demand, imports broken down by Eastern and Western Hemispheres, RFO production capability of the Western Hemisphere (Figure 15) percent of the Western Hemisphere production which must be imported to meet United States demand, and total world RFO supply potential versus U.S. demand (Figures 16, 17) expressed as a surplus or deficit. These items are tabulated for both the total RFO pool at "current sulfur level" and for the 0-1.0% sulfur portion of the RFO pool.

Part of the data in Table 22 was taken from Tables 7, 17 and 19. Supplemental data were obtained from the questionnaires (10) which provided the Western Hemisphere RFO production capability for the years 1970-75; total RFO production is shown as well as that at 0-1% sulfur level. Eastern Hemisphere imports for the years 1967-69 and Jan-May 1970 were obtained from the "Oil and Gas Journal" (6-e). Projected statistics relating mostly to 0-1% sulfur data are based on the following assumptions:

- The total increase in U.S. RFO demand for the period 1970-75 is due to the increase in demand for 0-1% sulfur RFO.
- The increase in potentially available RFO from the Eastern Hemisphere will decline from about 10% in 1971 to 4% in 1975, reflecting a strong increase in demand in the European market for low sulfur RFO.
- Domestic production of 0-1% sulfur RFO will slowly decrease due to the gradual percentagewise reduction in total RFO production.

FIGURE 14

VARIATION IN DEMAND FOR RESIDUAL FUEL OIL BY MONTH OF YEAR PROJECTED THROUGH 1975

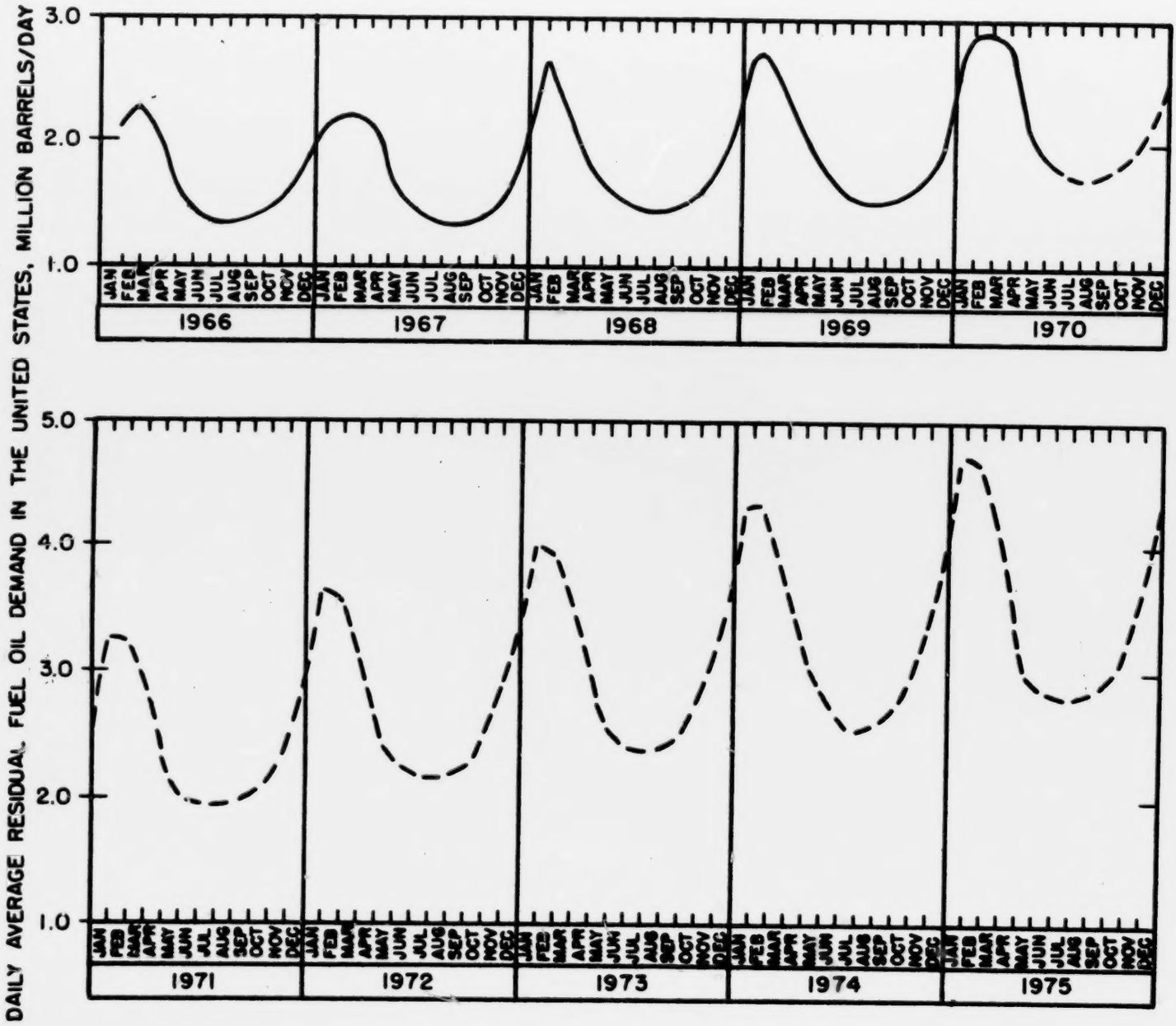


TABLE 22 (Part 1)

UNITED STATES RESIDUAL FUEL OIL SUPPLY/DEMAND STATISTICS, 1965-1975

Year	Domestic RFO Demand		Domestic RFO Production		RFO Imports Required To Meet Domestic Demand		Potential Supply Eastern Hemisphere		Required RFO Imports Western Hemisphere	
	Total	0-1.0%S	Total	0-1.0%S	Total	0-1.0%S	Total	0-1.0%S	Total	0-1.0%S
1965	1.608	-	0.735	0.183	0.873	-	-	-	-	-
1966	1.716	-	0.723	(0.177)	0.993	-	-	-	-	-
1967	1.786	-	0.756	(0.181)	1.030	-	0.067	-	0.963	-
1968	1.831	(0.332)	0.753	(0.177)	1.078	0.155	0.131	(0.019)	0.947	(0.136)
1969	1.978	(0.451)	0.728	(0.167)	1.250	0.284	0.158	(0.036)	1.092	(0.248)
1970	(2.208)	(0.681)	(0.730)	(0.164)	(1.478)	(0.517)	(0.210)	(0.073)	(1.268)	(0.444)
1971	(2.48)	(0.953)	(0.747)	(0.164)	(1.73)	(0.789)	(0.230)	(0.105)	(1.50)	(0.684)
1972	(2.75)	(1.223)	(0.762)	(0.164)	(1.99)	(1.059)	(0.250)	(0.133)	(1.74)	(0.926)
1973	(3.03)	(1.503)	(0.781)	(0.164)	(2.25)	(1.339)	(0.270)	(0.160)	(1.98)	(1.179)
1974	(3.30)	(1.773)	(0.796)	(0.163)	(2.50)	(1.610)	(0.280)	(0.180)	(2.22)	(1.430)
1975	(3.56)	(2.033)	(0.816)	(0.163)	(2.74)	(1.870)	(0.290)	(0.198)	(2.45)	(1.672)

All quantities are daily averages in millions of barrels per calendar day.
Eastern hemisphere refers to western Europe and Middle East.
Western hemisphere includes the following areas: Venezuela, Netherlands Antilles, Trinidad, Virgin Islands and Bahamas.
Quantities shown in brackets are estimated or calculated.
Changes in domestic stocks, exports from U.S. and transfers from crude oil have been neglected.
Totals shown are for overall RFO pool at current sulfur level.

TABLE 22 (Part 2)

UNITED STATES RESIDUAL FUEL OIL SUPPLY/DEMAND STATISTICS, 1965-1975

Year	RFO Production Capability of Western Hemisphere as Defined (Does not include U.S. Production)			Per Cent of Western Hemisphere Production Which Must be Imported To Meet U.S. Demand		Total World RFO Supply Potential Versus U.S. Demand Surplus(+), Deficit(-)	
	Total	0-1.0%S	0-0.5%S	0-0.3%S	Total (%)	0-1.0%S (%)	Total	0-1.0%S
1965	1.350	-	-	-	-	-	-	-
1966	1.322	-	-	-	-	-	-	-
1967	1.340	-	-	-	71.8	-	+0.377	-
1968	1.414	-	-	-	67.0	-	+0.467	-
1969	1.498	-	-	-	72.9	-	+0.406	-
1970	1.69	0.55	-	0.156	(75.0)	(80.7)	(+0.422)	(+0.138)
1971	(1.82)	(0.62)	-	0.156	(82.4)	(110.3)	(+0.317)	(-0.064)
1972	(1.93)	0.70	-	0.216	(90.1)	(132.2)	(+0.192)	(-0.226)
1973	2.04	0.97	-	0.266	(97.0)	(121.5)	(+0.061)	(-0.209)
1974	2.13	1.06	-	0.266	(104.2)	(134.9)	(-0.094)	(-0.370)
1975	(2.25)	(1.14)	-	0.266	(108.9)	(146.7)	(-0.204)	(-0.532)

Refer to Part 1 of Table 22 for notes applicable to above.
Quantities of 0-1.0% S and 0-0.3% S are not additive.

FIGURE 15

TOTAL CRUDE THROUGHPUT AND RFO PRODUCTION CAPABILITY

OF

VENEZUELA, NETHERLANDS ANTILLES, TRINIDAD,

VIRGIN ISLANDS AND THE BAHAMAS,

1965 – 1975

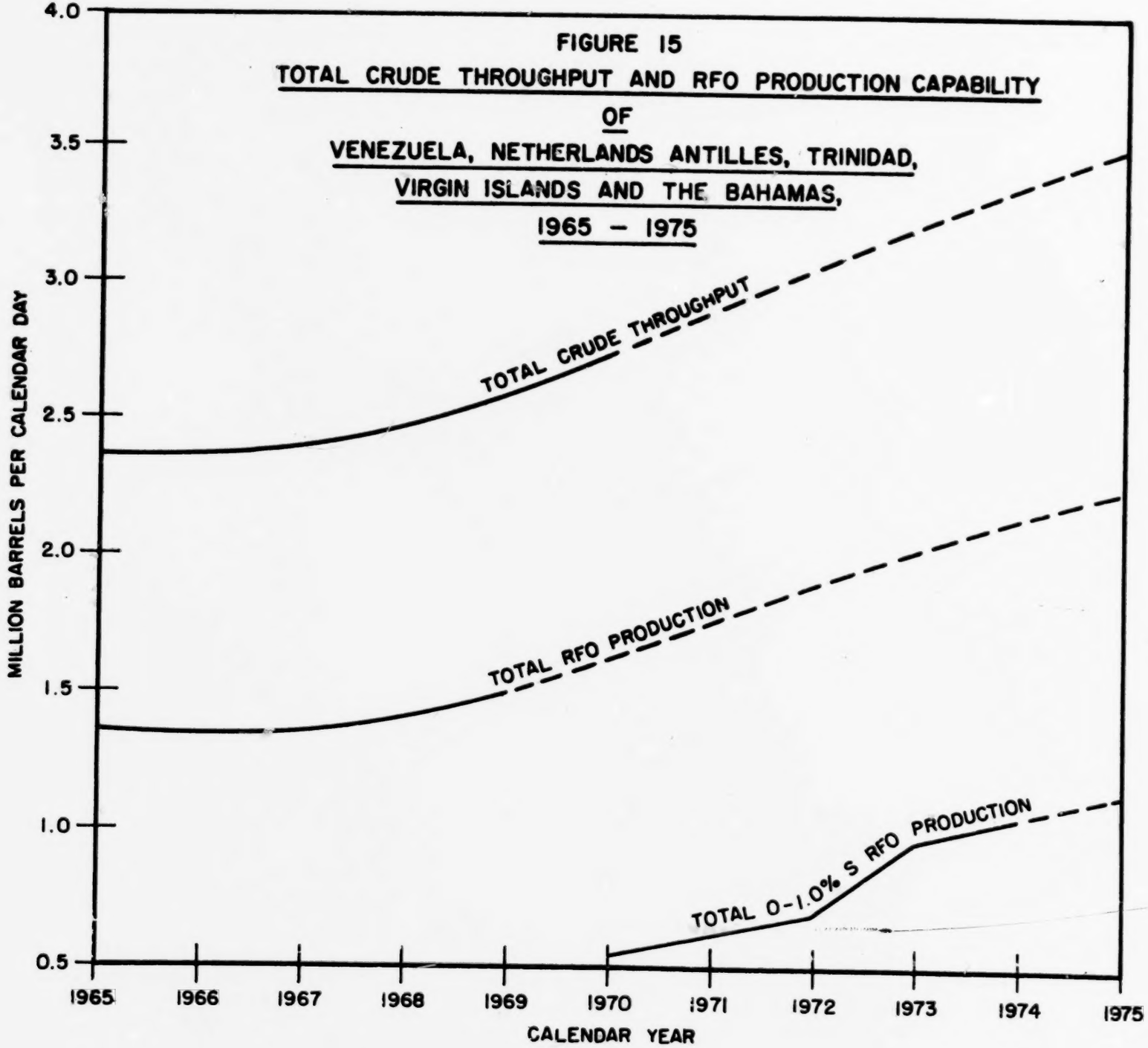


FIGURE 16

TOTAL UNITED STATES RFO DEMAND

AND

WORLD RFO SUPPLY POTENTIAL

(NO SULFUR LIMITS), 1965 – 1975

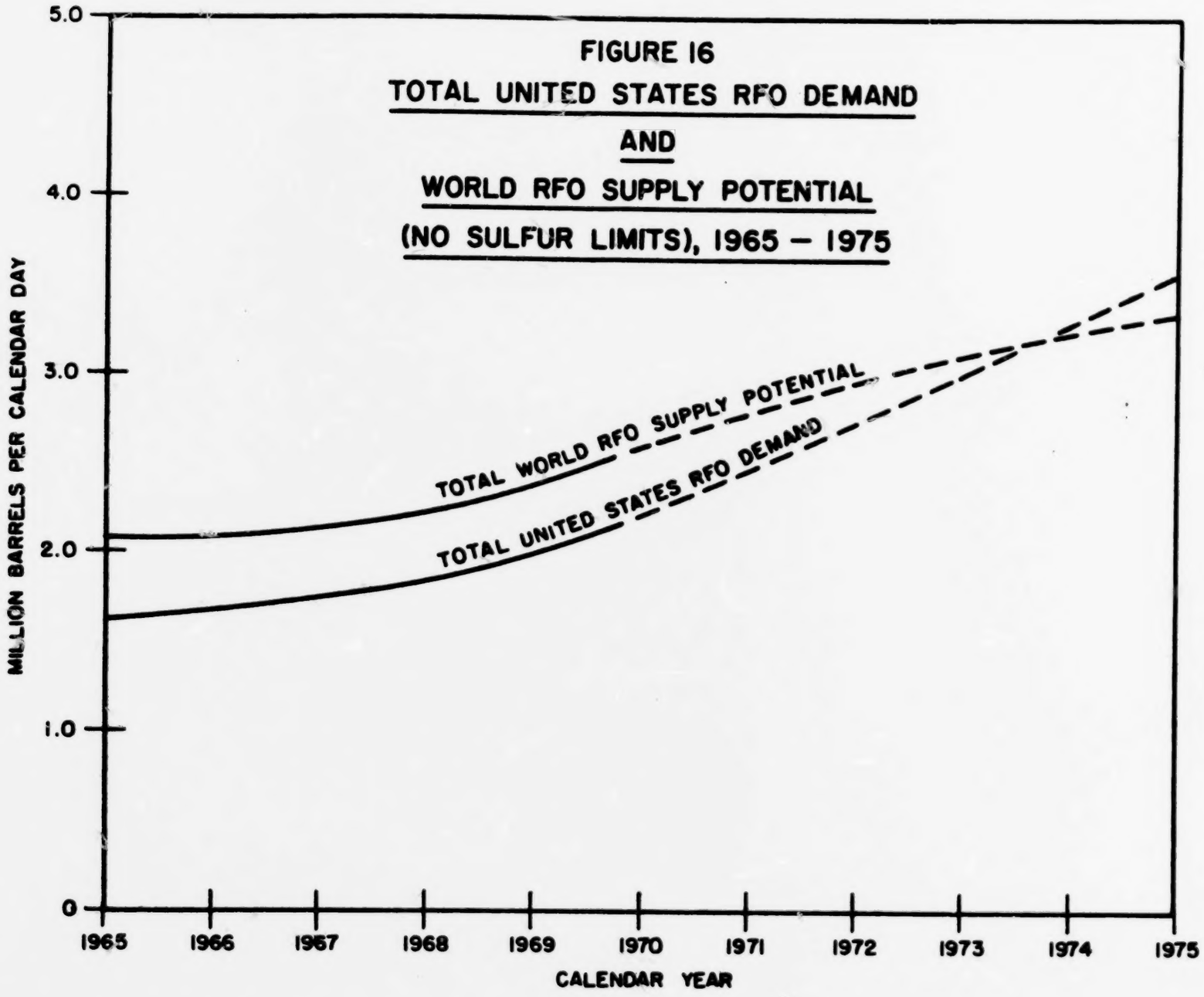


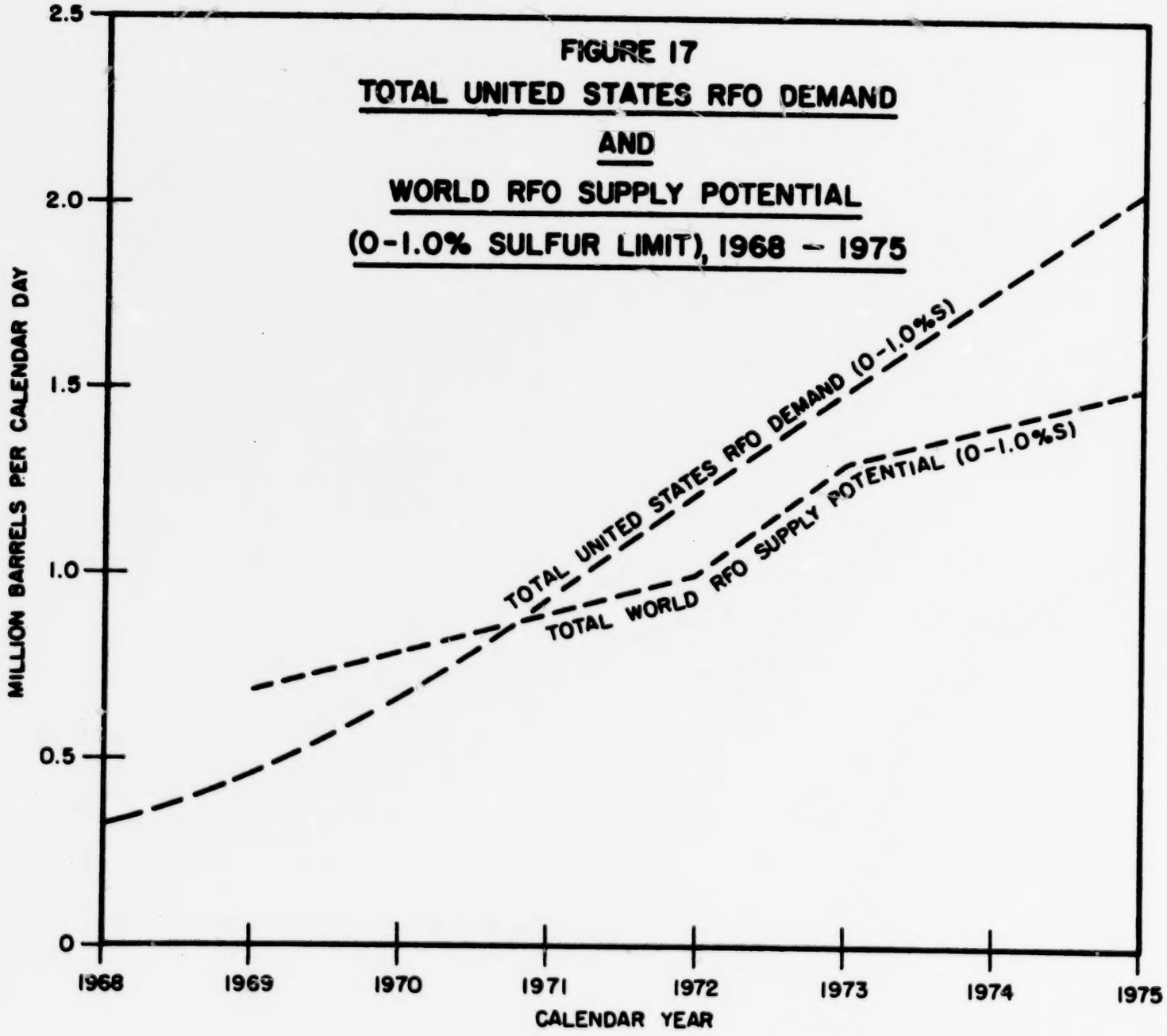
FIGURE 17

TOTAL UNITED STATES RFO DEMAND

AND

WORLD RFO SUPPLY POTENTIAL

(0-1.0% SULFUR LIMIT), 1968 – 1975



B. Economics

Table 23 presents the economics of producing low sulfur RFO in the United States. The base case was derived from published information (6-a) while cases 1 and 2 were developed on the same basis as the base case using actual production statistics for 1969 and projected statistics for 1973. Incremental costs and capital investment costs for producing RFO at sulfur levels of 1.0% W and 0.5% W are tabulated individually for PAD districts 1-5 and for the overall United States. Plots of incremental production costs and capital investment as a function of time for the period 1967-73 are shown in Figures 18-22.

The base case of the reference study was developed by setting up an "average" refinery for each of the five PAD districts. Parameters were established for variables such as crude properties, product slate, product characteristics, processing schemes and RFO blending requirements for each average refinery. Using the latest available refinery statistics for the period 1964-65 the economics of low sulfur RFO production were calculated, at 1967 cost levels, from which the incremental cost of fuel oil production and overall capital investment requirements for each of the five refineries were established. Two different sulfur levels, viz., 1.0% W and 0.5% W, were evaluated for each case.

Using the crude throughputs and RFO production statistics from Table 19, similar economics have been calculated for two additional cases for the years 1969 and 1973. The basic assumptions of the original study

TABLE 23

ECONOMICS OF PRODUCING LOW SULFUR RESIDUAL FUEL OIL IN THE U.S.

% Sulfur in Desulfurized No. 6 Fuel Oil Product	District (PAD) 1		2		3		4		5		Overall U.S.	
	1.0%	0.5%	1.0%	0.5%	1.0%	0.5%	1.0%	0.5%	1.0%	0.5%	1.0%	0.5%
Base Case - 1964 Production Statistics & 1967 Economics(1)												
Total HDS Capacity, Bbl/CD	83000	83000	None Required	151000	None Required	135000	30000	30000	196000	196000	309000	595000
Total On Site Invest, MM$	58.20	69.36		142.80		115.94	31.27	37.50	116.70	126.65	206.17	492.25
Total Overall Invest, MM$	89.16	106.08		217.98		177.32	47.85	57.30	178.33	193.46	315.34	752.14
Cash Flow/Unit, $/Day	4070	4830		2840		3130	1750	2090	5750	6230	11570	19120
Oper. Cost/Unit, $/Day	4372	5527		3565		3858	2625	3435	5627	6507	12624	22892
New Products/Unit, Bbl/CD	11920	12250		4920		5935	2980	3062	19570	20110	34470	46277
Incremental FO Cost, $/Bbl	0.71	0.85		1.30		1.18	1.47	1.80	0.58	0.64	0.70	0.91
Case I - 1969 Production Statistics & Economics												
Total HDS Capacity, Bbl/CD	79900	79900	None Required	144100	None Required	160100	23100	23100	160700	160700	263700	568000
Total On Site Invest, MM$	62.04	74.19		146.03		151.51	27.04	32.50	105.60	115.08	194.68	579.31
Total Overall Invest, MM$	93.72	112.15		220.75		229.10	40.96	49.20	160.0	174.04	294.68	785.24
Cash Flow/Unit, $/Day	4231	5121		2749		4184	1399	1685	5492	5960	11172	19699
Oper. Cost/Unit, $/Day	4291	5425		3301		4736	1999	2602	5005	5786	11295	21850
New Products/Unit, Bbl/CD	11466	11794		4452		7208	2184	2245	17010	17496	30660	43195
Incremental FO Cost, $/Bbl	0.75	0.89		1.36		1.24	1.56	1.91	0.62	0.67	0.73	0.96
Case II - 1973 Projected Production Statistics & Economics												
Total HDS Capacity, Bbl/CD	85150	85150	None Required	154000	None Required	173900	23340	23340	174500	174500	283000	610800
Total On Site Invest, MM$	85.44	101.76		200.76		211.11	35.4	42.45	148.07	160.65	268.91	716.73
Total Overall Invest, MM$	129.18	153.85		303.54		319.20	53.52	64.17	223.87	242.89	406.57	1083.65
Cash Flow/Unit, $/Day	5899	7025		3960		5642	1955	2344	7216	7828	15070	26799
Oper. Cost/Unit, $/Day	5021	6348		4046		5467	2365	3080	5622	6499	13008	25440
New Products/Unit, Bbl/CD	12212	12560		4982		7574	2353	2420	17378	17873	31943	45409
Incremental FO Cost, $/Bbl	0.89	1.06		1.61		1.47	1.83	2.24	0.74	0.80	0.88	1.15

(1) OGJ, April 29, 1968, pp. 55-63; May 13, 1968 pp. 90-95

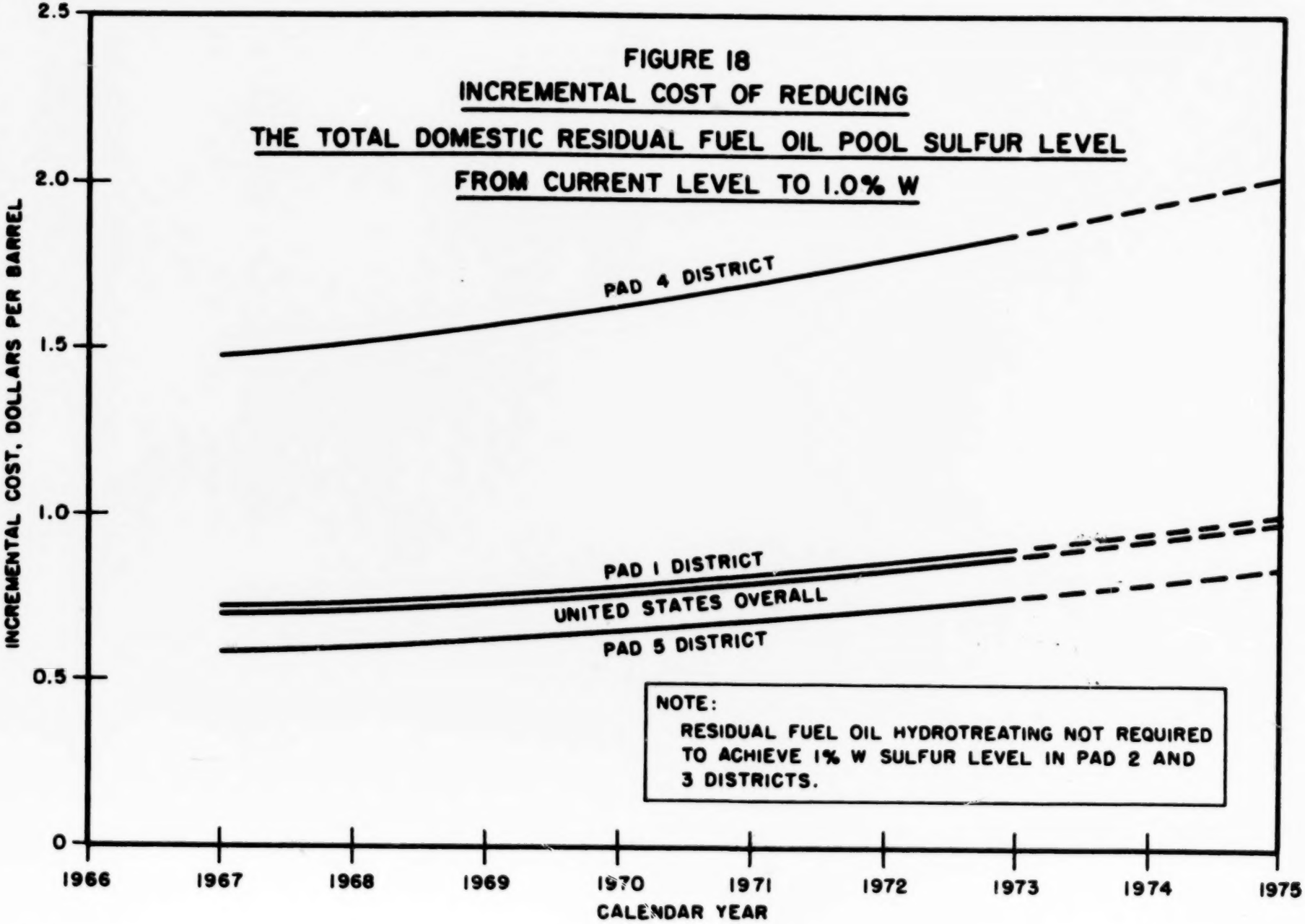


FIGURE 18
INCREMENTAL COST OF REDUCING
THE TOTAL DOMESTIC RESIDUAL FUEL OIL POOL SULFUR LEVEL
FROM CURRENT LEVEL TO 1.0% W
INCREMENTAL COST, DOLLARS PER BARREL
2.5
2.0
1.5
1.0
0.5
0
PAD 4 DISTRICT
PAD 1 DISTRICT
UNITED STATES OVERALL
PAD 5 DISTRICT
NOTE:
RESIDUAL FUEL OIL HYDROTREATING NOT REQUIRED TO ACHIEVE 1% W SULFUR LEVEL IN PAD 2 AND 3 DISTRICTS.
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
CALENDAR YEAR

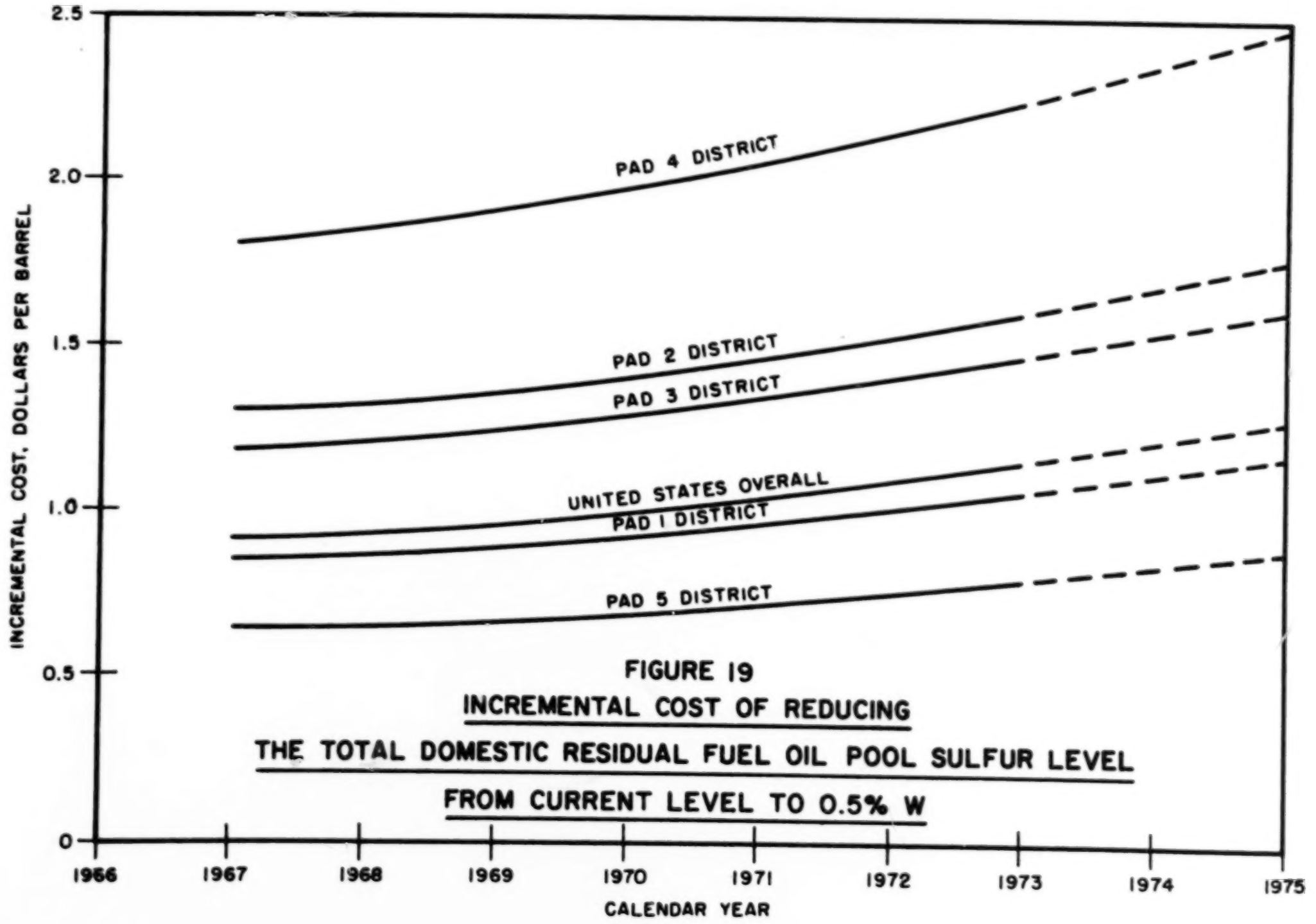


FIGURE 19

INCREMENTAL COST OF REDUCING

THE TOTAL DOMESTIC RESIDUAL FUEL OIL POOL SULFUR LEVEL

FROM CURRENT LEVEL TO 0.5% W

FIGURE 20

CAPITAL INVESTMENT REQUIRED TO REDUCE

THE TOTAL DOMESTIC RESIDUAL FUEL OIL POOL SULFUR LEVEL

FROM CURRENT LEVEL TO 1.0% W

(ONSITES AND TOTAL OVERALL INVESTMENT SHOWN SEPARATELY)

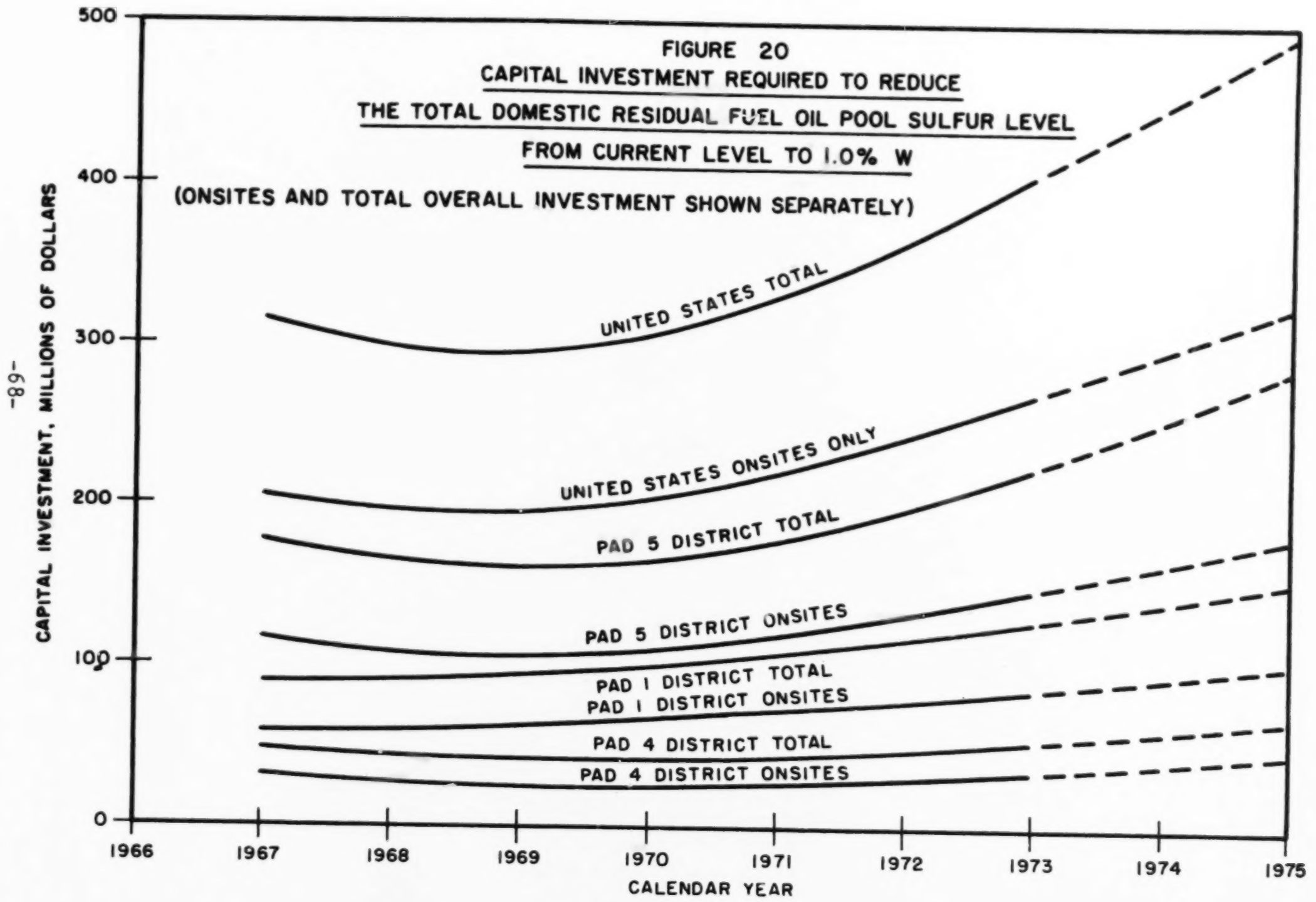


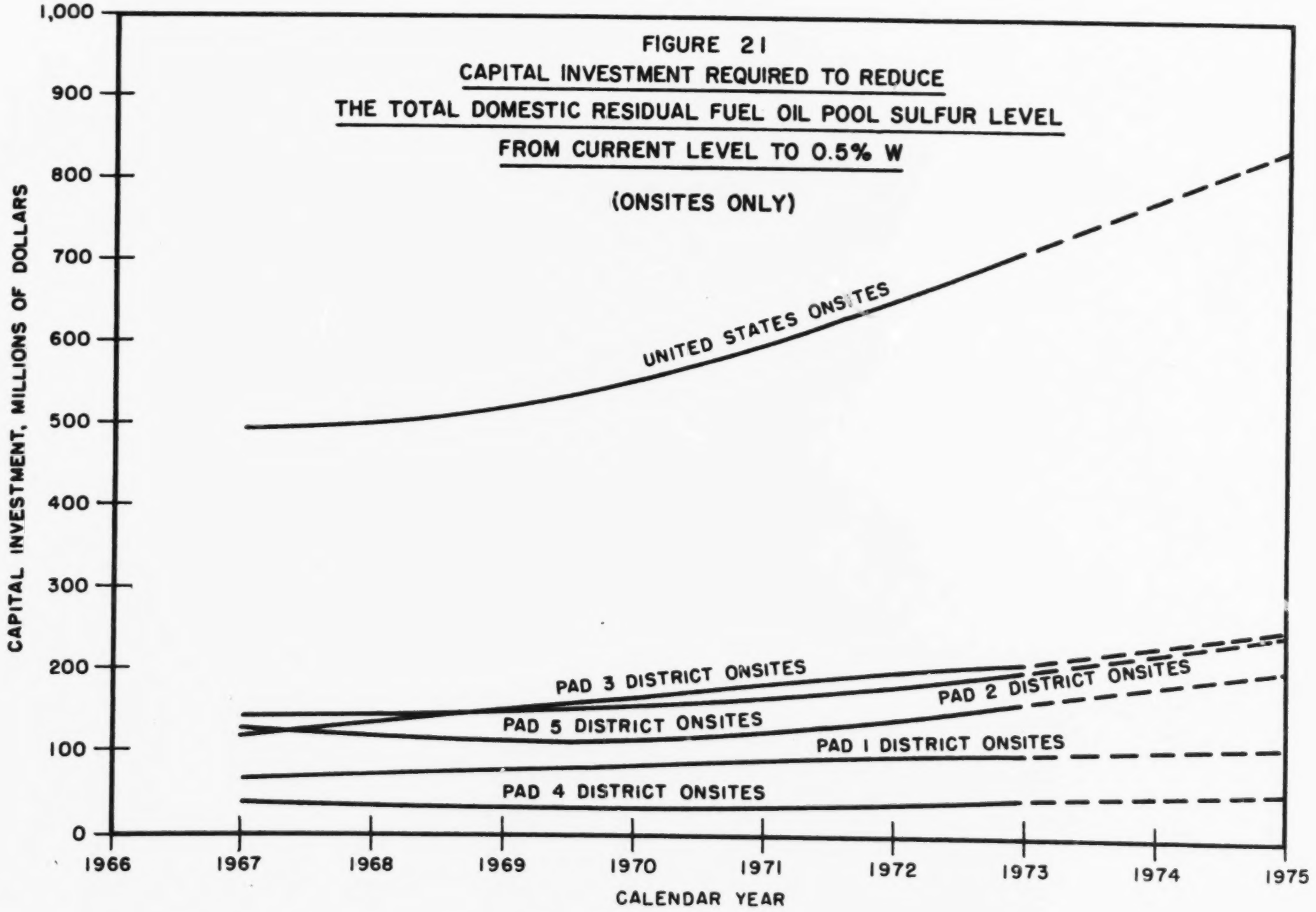
FIGURE 21

CAPITAL INVESTMENT REQUIRED TO REDUCE

THE TOTAL DOMESTIC RESIDUAL FUEL OIL POOL SULFUR LEVEL

FROM CURRENT LEVEL TO 0.5% W

(ONSITES ONLY)



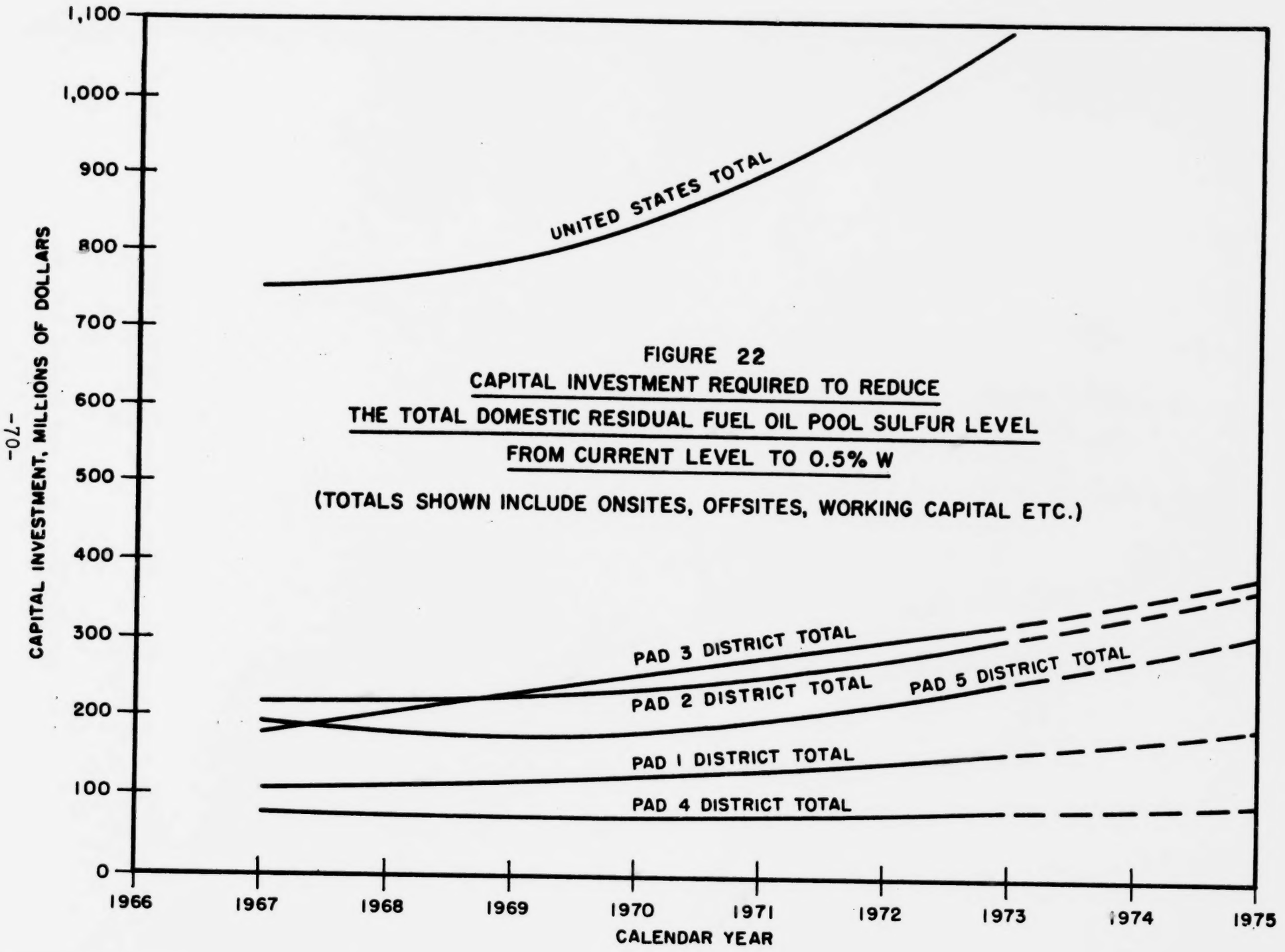


FIGURE 22

CAPITAL INVESTMENT REQUIRED TO REDUCE

THE TOTAL DOMESTIC RESIDUAL FUEL OIL POOL SULFUR LEVEL

FROM CURRENT LEVEL TO 0.5% W

(TOTALS SHOWN INCLUDE ONSITES, OFFSITES, WORKING CAPITAL ETC.)

remain valid since the domestic RFO pool sulfur content has been reasonably constant over the period 1964-67 (Figure 4) notwithstanding the deeper bite taken into the heavy residuum and the resulting concentration of sulfur in a diminishing RFO volume. The maintenance of a constant sulfur level in the RFO pool has been accomplished primarily by blending desulfurized cutter stock with high sulfur residuum, a procedure which has entailed substantial investment in gas oil desulfurizing units and heavy residuum conversion units on a continuing basis. It should be noted that this category of investment will continue to be required to meet projected future RFO production schedules at current sulfur levels and is not included in the calculated incremental cost of producing 1.0% W and 0.5% W RFO.

A basic assumption made in the reference study is that the cutter stock used for blending is already desulfurized. The incremental costs shown for all three cases are in addition to routine expenditures for the maintenance of a constant current sulfur level and reflect the cost of hydrotreating and other auxiliary facilities for the desulfurization of the heavy residuum which is required to reach the low sulfur levels desired.

Referring to the base case of Table 23 it was calculated that owing to the lower sulfur content of the crudes run in PAD districts 2 and 3 the RFO pool sulfur content in these two districts could be reduced to 1.0% W by blending with desulfurized cutter stock thereby eliminating the need to desulfurize the heavy residuum. In PAD districts 1, 4 and 5, however, heavy residuum desulfurization is required to reach the 1.0% W sulfur level. To achieve the 0.5% W sulfur level it is necessary to partially desulfurize the heavy residuum in all five PAD districts.

VI. ANALYSIS OF FUEL OIL SITUATION--PRESENT AND FUTURE

A. Domestic RFO Production

1. Current Sulfur Levels--Existing Refineries

Historically the production of residual fuel oil in the United States has steadily decreased both in terms of absolute number of barrels and volume percent (% V) of crude run (Table 19). In 1960 domestic RFO production totaled 332 million barrels (MM bbl) representing 11.25% V of crude run; by 1969, however, RFO production had decreased to 266 million barrels representing 6.85% V of crude run. This policy of reducing RFO production has been methodically carried out to increase overall refinery profits by maximizing the production of the more valuable products such as gasoline and light distillates. To accomplish this reduction a large capital investment has been expended for equipment specifically designed for the conversion of heavy petroleum fractions.

The RFO production projections for the period 1971 through 1975 (Table 19) have been made assuming that on a long term basis the above trend (i.e., minimizing production of RFO) will continue but that the rate of decrease in volume percent of RFO on crude run is leveling off (Figure 12). It is recognized, of course, that on a short term basis (e.g., the 1970-71 winter season) temporary factors can reverse this trend such that RFO production is increased above the rates shown in Table 19. Factors influencing the 1970-71 RFO production rate include a tanker shortage, high RFO prices, and announcements by the industry that RFO production will be increased by 100,000 barrels per calendar day (BCD) during

this period. However, it is believed that the trend to reduce RFO production is valid on a long term basis and would only be reversed permanently if the short term factors become more pronounced and permanent. Therefore, it is expected that average domestic production over the next five years, at the current sulfur level of 1.65 to 1.85 weight percent, will be in the 750,000 to 850,000 BCD range.

2. Low Sulfur Levels--Existing Refineries

The Bureau of Mines annual petroleum products survey entitled "Burner Fuel Oils" (1-a) is the only published comprehensive data source relating to the sulfur content of domestic RFO. However, as pointed out in section IV of this report, these data are arithmetic averages based on a limited sampling of the domestic RFO pool and therefore cannot be used to calculate either the overall RFO pool weighted sulfur average or the percentage of the total production which is in the 0-1.0% sulfur range.

For this reason it has been necessary to use secondary sources as a basis for quantitatively estimating the extent of low sulfur domestic RFO production.

One study (6-a) has been made from which it was concluded that existing refineries without modification were capable of reducing approximately 35% of the total RFO pool to the 0-1% level by blending with desulfurized cutter stocks while maintaining acceptable flash point and viscosity values. A second study (6-b) in which the actual 1965 RFO production statistics were obtained by polling the refiners, showed that overall, approximately 25% of the total domestic RFO production was at the 1% sulfur level. Using the latter study as a basis, the estimated 0-1% sulfur RFO production for 1965 was 183,000 BCD. Therefore, the average domestic production of 0-1% sulfur RFO over the next five years is estimated to be in the 150,000 to 175,000 BCD range. Since the domestic production of 0-1% sulfur RFO is expected to be essentially constant for the next 5 years while the domestic demand will increase, the estimated deficit between supply and demand increases from 83% in 1971 to 92% in 1975; that is, domestic production will satisfy 17% of the domestic demand for 0-1% sulfur RFO in 1971 but only 8% in 1975 (Table 22, Part 1, Columns 2 & 4).

3. Low Sulfur Levels--Existing Refineries Plus Hydrotreating

The RFO production rates projected for 1971-75 are shown in Table 19; these rates are based on pool sulfur levels of 0.5% W and 1.0% W and it is assumed that hydrotreating facilities have been installed. For the period covered, RFO production at the 1.0% W sulfur level is in the 675,000 to 750,000 BCD range--down 10% from production at current sulfur levels. Production at the 0.5% W sulfur level is in the 550,000 to 625,000 BCD range--down 25% from production at current sulfur levels. These production statistics are based on lowering the total domestic RFO pool by hydrotreating the heavy residuum. Short term market factors have been neglected and it is assumed 1) that there is a uniform demand for low sulfur fuel oil throughout the United States, and 2) that the selling price has increased by an amount at least equal to the incremental cost of production. Since domestic production will provide only 23% of the total United States demand for RFO in 1975, it is unlikely that sufficient incentive will be generated to justify reducing the RFO pool sulfur level by this route, i.e., hydrotreating the heavy residuum. Currently it appears that the present method comprising gas oil desulfurization, selective blending, and minimization of heavy RFO production by conversion to other products will continue to be the most attractive solution to the heavy ends disposal problem.

4. Economics of Low Sulfur RFO

The economic data developed by the method described in section V-B of this report are tabulated in Table 23 and plotted on Figures 18-22.

The systematic reduction of the domestic RFO pool sulfur level would require capital investments on the order of 300 to 400 million dollars to reach the 1.0% W sulfur level and 700 to 1100 million dollars to reach the 0.5% W sulfur level. (Note that these expenditures are in addition to the current investments now being expended for gas oil desulfurization and residuum conversion which have been required to maintain the current sulfur level almost constant for the previous five years.) A desulfurization program of this magnitude would require 3 to 5 years to implement and is dependent on the existing technology of desulfurizing heavy residuum. Recent industry developments do indicate that the degree of residuum desulfurization required, i.e., removal of 50-60% of the total sulfur, is feasible; however, since the type of unit and the special catalyst required have not been extensively tested in commercial service, the estimated costs are order of magnitude accuracy.

The incremental cost of producing low sulfur RFO varies widely by PAD district (Table 23). At the 1.0% sulfur level it is $0.75 to $0.90 per barrel in PAD district 1 and $1.50 to $1.85 per barrel in PAD district 4 with an overall United States average in the $0.75 to $0.90 per barrel range. At the 0.5% W sulfur level incremental costs add $0.90 to $1.10 per barrel in PAD district 1 and $1.80 to $2.25 per barrel in PAD district 4 while the overall United States average is in the

$0.95 to $1.15 per barrel range. For comparison, actual spot prices for No. 6 RFO in New York Harbor on 9/28/70 show an incremental cost of $0.55 to $1.05 per barrel for 1.0% sulfur No. 6 fuel oil versus no sulfur guarantee No. 6 fuel oil which contains in excess of 2.2% sulfur.

5. Future Desulfurization Plants--United States

Federal restrictions relating to the processing of imported fuel oils have been relaxed and the Oil Import Administration has issued allocations permitting the import of quantities of high sulfur residuum for further processing. There are at present three companies planning to construct U.S.-based refineries designed to produce low sulfur RFO by processing imported high sulfur residuum and topped crude. These plants have a planned total production capacity of 265,000 BCD of RFO with a sulfur content in the 0-1.0% range. Approximately 70,000 BCD will contain less than 0.5% sulfur.

The above plants have not yet been built due in part to the difficulties encountered in obtaining suitable construction sites. Since at the present time a definite production schedule cannot be predicted, the output from these plants has not been included in tne estimated domestic production capability statistics for 1971-75 (Table 22).

B. Foreign RFO Supplies

1. Eastern Hemisphere Imports

Imports from the Eastern Hemisphere (Western Europe and the Middle East) comprised less than 5% of the total RFO imported into the United States during the early 1960's. By 1969 Eastern Hemisphere imports had increased to 12.6% of the total (158,000 BCD) and during the first five months of 1970 had further increased to 14.2% of the total (210,000 BCD). This rapid increase in imports during 1969 and 1970 was largely owing to the increased demand for low sulfur RFO in the United States accompanied by large price increases in 1970.

Western Europe is on balance a net importer of RFO, but due to the availability of low sulfur African crudes, it recently has increased production of low sulfur RFO of which a growing percentage is available for export. Concurrently, however, the demand growth rate for RFO in Western Europe has increased proportionately as much as it has in the United States. For this reason it is doubtful that the rapid rate of increase in RFO imports from Western Europe attained during 1969 and 1970 can be sustained during the 1971-75 period.

The potentially available RFO imports from the Eastern Hemisphere have been estimated conservatively (Table 22, Part 1) at 225,000 to 300,000 BCD for the period 1971-75. Of this amount 100,000 to 200,000 BCD will have a sulfur content in the 0 to 1.0% range. These estimates are based on a conservative growth rate which would be expected for petroleum products rather than the much higher growth rate achieved by Eastern Hemisphere RFO imports during 1969 and 1970.

2. Western Hemisphere Imports

The Western Hemisphere referred to here and in Table 22 comprises Venezuela, Trinidad, the Netherlands Antilles, the Virgin Islands and the Bahamas. Actual RFO production from this area for the period 1965-69 averaged 1,385,000 BCD of which approximately 70% was imported into the United States (Table 22, Part 2).

Production capability statistics for the period 1970-75 were obtained from questionnaires (10) submitted to those refineries whose output comprises the major portion of the RFO production capacity in the Western Hemisphere. From these questionnaire data it is estimated that total RFO production capability will increase by about 6% per year; i.e., from 1,690,000 BCD in 1970 to 2,250,000 BCD in 1975. Production capability of RFO with sulfur content in the 0 to 1.0% range will increase by about 16% per year--from 550,000 BCD in 1970 to 1,140,000 BCD in 1975. The "current sulfur level" of imported RFO was 2.5% in 1964 (6-c). It had decreased to about 2.0% by 1969 (Table 7) and will decrease to around 1.5% by 1975 when approximately 68% of all RFO produced in the Western Hemisphere will have a sulfur content in the 0 to 1.0% range. A discussion of Western Hemisphere RFO imports into the United States is presented in the following section of this report.

C. World-United States Supply/Demand

The overall RFO supply/demand statistics for the United States for the period 1965-75 are summarized in Table 22. On a total basis (no sulfur limit) the world RFO supply potential versus United States demand shows a substantial surplus through 1972, becomes marginal during 1973-74, and then shows a substantial deficit in 1975. (It should be noted that the "world RFO supply potential" is defined as the quantity that can be imported from the Eastern Hemisphere plus the entire production from the Western Hemisphere.) For example, in 1975 the RFO needed from the Western Hemisphere exceeds their total production by about 10% (2,450,000 BCD required vs 2,250,000 BCD produced). To meet the demand during the period 1970-73 requires increasing the percentage of total Western Hemisphere production imported into the United States from 73% in 1969 to 97% in 1973. Importing this amount (75-100% of production) would create supply problems for those consumers now using the RFO which is not imported into the United States. Thus, from Table 22 (Part 2) it can be seen that after 1973 there would be no RFO left for consumption within the Western Hemisphere. If, in fact, it is not possible for the United States to import the quantities shown, as is the most likely case, then the supply potential would decrease and the United States RFO deficit would occur sooner than predicted in Table 22. However, the available published statistical data are not presented in sufficient detail to enable making the analysis required to resolve this latter point.

The preceding analysis is based on the assumption that the Eastern Hemisphere imports will be limited to the

amounts shown in Table 22 (Part 1) which represent only a small percentage (<20%) of the total production in this area. If the quantity imported from the Eastern Hemisphere could be increased, the required Western Hemisphere imports would, of course, decrease by the same amount.

The world supply potential of RFO with a sulfur content in the 0 to 1.0% range versus United States demand for this product shows a modest surplus for 1970, a marginal deficit for 1971 and a substantial deficit for 1972-75. Since the United States is currently receiving essentially all of the Western Hemisphere output of low sulfur RFO, the potential supply problem which is applicable to the total RFO production should not arise.

The factors influencing the world RFO supply potential and United States demand are exceedingly complex and subject to change. Therefore, the conclusions to be drawn from the statistics presented in Table 22 should be viewed as being indicative of representative trends rather than as firm quantitative values. However, it is reasonable to conclude that unless substantial permanent improvement is made in the world supply situation or United States demand is reduced by removing sulfur restrictions on all fossil fuels, the United States will experience a RFO shortage no later than the 1973-75 period. An exact determination of the extent of this shortage would require considerably more data than are now obtainable either from published statistics or from questionnaires.

The situation with respect to low sulfur RFO is considerably worse than the total supply picture since the deficit will begin in 1971 and become progressively worse

through 1975. Several geographical areas have established or are contemplating the establishment of 0.5%, 0.37%, or 0.3% sulfur limits on RFO. Only a limited amount of this very low sulfur RFO is presently available; however, since published statistics are not available the quantitative effect of the demand for very low sulfur RFO on the overall supply picture cannot be determined. Directionally the total RFO supply potential will be reduced thereby aggravating the low sulfur RFO deficit predicted for 1971-75.

It should be kept in mind that the foregoing supply/demand analysis is concerned with overall nation-wide conditions. Local, temporary shortages caused by distribution problems, inadequate storage facilities, switchover from coal to oil-burning facilities, unusually cold weather, etc., can and probably will occur independently of and prior to the nation-wide deficit shown in Table 22.

D. Potential Methods of Increasing United States RFO Supply

The world RFO supply potential is currently in the process of adjusting to an unprecedented increase in world demand, with the situation further complicated by the introduction of sulfur content limitations imposed by regulatory agencies. This adjustment is being carried out subject to import restrictions, a tanker shortage, pipeline shutdowns and other short term adverse factors.

Assuming that the projected demand statistics which have been presented in this report are reasonably accurate, it is concluded that the United States will experience a shortage in the total RFO supply within the next three to four years and a shortage of low sulfur RFO in the coming year. The indications are that perhaps the industry did not foresee the magnitude of the demand increase and consequently fell short in its plans to fill this need. Conversely it is equally logical to assume that since the current high demand growth rate in the United States is largely the result of the imposition of sulfur limitations on fossil fuels, the arbitrarily set sulfur levels may not be compatible with the capability of the industry to respond within the available time span. The resolution of this problem depends not only on how the industry plans to overcome the predicted shortage but also on the establishment on a nation-wide basis, of more realistic sulfur limitation goals both with respect to allowable RFO sulfur content and the time available for implementation.

Coupled with these considerations should be a realization that the cost of cleaner air will be substantial,

particularly during the interim years when processing facilities are being installed on an accelerated basis and before competitive economics have had a chance to become fully operative.

It appears that the industry response to the present demand situation has been a productive one and that a continuance of the same techniques on an accelerated basis should result in a satisfactory solution to the RFO shortage problem.

The following discussion relates to the three methods now being employed to meet current demand for RFO in the United States.

1. Increased Domestic Production

Production of RFO during the 1970-71 winter season has been increased by 100,000 to 200,000 BCD consisting primarily of high sulfur oil. It is believed that this incremental production should be continued as long as required and increased if necessary. Although this expedient provides a partial short term solution to the current demand situation, it is not responsive to the impending low sulfur RFO shortage. Therefore, as part of the long term solution of the air pollution problem, the industry should provide for gradual reduction of the current sulfur level of the domestic RFO pool to below the 1.0% level.

2. Increased Eastern Hemisphere Imports

Increasing the quantity of imported low sulfur RFO from Western Europe is the most convenient short term solution to the predicted shortage of this material. Since this is essentially a competitive market, RFO prices can be expected to rise above current levels if domestic demand for low sulfur RFO during 1971 is to be met without a relaxation of proposed sulfur limitations on the Eastern Seaboard.

Long term reliance on the European market for low sulfur RFO supplies, however, does not appear to be as stable and economical a solution to the supply problem as does increasing both domestic and Western Hemisphere production of this material. Since the reasons for this are discussed on Page 7 of this report they will not be reported here.

3. Increased Western Hemisphere Imports

The presently planned expansion of the RFO production capability of the Western Hemisphere will satisfy a major part of domestic requirements for high and low sulfur RFO over the next five years. However, on the basis of the questionnaire data received from these refineries, it would appear that the planned expansion over this period is inadequate to meet predicted total requirements. Since there is no indication of an

industry trend to substantially increase the domestic production of low sulfur RFO, it is essential that planned expansion of the Western Hemisphere facilities be accelerated and increased rather than to continually increase our reliance on Eastern Hemisphere imports. Factors which are required for rapid expansion in the former producing region are availability of low sulfur African crudes, a market for the light fractions resulting from topping crude and a guarantee of an adequate, stable price incentive which will justify economically the installation of the needed facilities.

VII. GLOSSARY

API:	American Petroleum Institute
Bbl/Day:	Barrels Per Day
BCD:	Barrels Per Calendar Day
¢/Bbl:	Cents Per Barrel
¢/Bbl-Mile:	Cents Per Barrel Per Mile
¢/100 Lb:	Cents Per Hundred Pounds
¢/100 Lb-Mile:	Cents Per Hundred Pounds Per Mile
$/Bbl:	Dollars Per Barrel
DFO:	Distillate Fuel Oil (Grades 1, 2)
FO:	Fuel Oil
HDS:	Hydrodesulfurization
Hi-Sul:	High Sulfur Content
Low-Sul:	Low Sulfur Content
Max 1% S:	Maximum 1% Sulfur Content
MM Bbl/CD, or MMBCD:	Million Barrels Per Calendar Day
MM$:	Millions of Dollars
NSG:	No Sulfur Guarantee
OGJ:	Oil and Gas Journal
PAD:	Petroleum Administration for Defense
Reg:	Regular Grade
RFO:	Residual Fuel Oil (Grades 4, 5, 6)
USBM:	United States Bureau of Mines
USDI:	United States Department of the Interior
Vol. %, or % V:	Volume Percent
Wt. %, or % W:	Weight Percent

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